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GEOLOGICAL SURVEY OF OHIO

J. A. BOWNOCKER, State Geologist

FOURTH SERIES, BULLETIN 13

THE MAXVILLE LIMESTONE

By WILLIAM CLIFFORD MORSE

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Published by authority of the Legislature of Ohio, under the supervision of the State Geologist

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COLUMBUS, OHIO, NOVEMBER, 1910

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To Governor Judson Harmon:

Dear Sir:—Herewith is submitted the manuscript of Bulletin 13 of the Geological Survey of Ohio, entitled "The Maxville Limestone." It is the work of Mr. William Clifford Morse, who has pursued this problem with energy for several years, and in large part at his own expense. It constitutes an addition to our knowledge of the stratigraphy of Ohio.

Respectfully submitted,

J. A. Bownocker,
State Geologist.

Columbus, November 28, 1910.

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THE SURVEY IN ITS RELATIONS TO THE PUBLIC.

The usefulness of the Survey is not limited to the preparation of formal reports on important topics. There is a constant and insistent desire on the part of the people to use it as a technical bureau for free advice in all matters affecting the geology or mineral industries of the State. A very considerable correspondence comes in, increasing rather than decreasing in amount, and asking specific and particular questions on points in local geology.

The volume of this correspondence has made it necessary to adopt a uniform method of dealing with these requests. Not all of them can be granted, but some can and should be answered. There is a certain element of justice in the people demanding such information, from the fact that the geological reports issued in former years were not so distributed as to make them accessible to the average man or community today. The cases commonly covered by correspondence may be classified as follows:

1st. Requests for information covered by previous publications.—This is furnished where the time required for copying the answer is not too large. Where the portion desired cannot be copied, the enquirer is told in what volume and page it occurs and advised how to proceed to get access to a copy of the report.

2nd. Requests for identification of minerals and fossils.—This is done, where possible. As a rule, the minerals and fossils are simple and familiar forms, which can be answered at once. In occasional cases, a critical knowledge is required and time for investigation is necessary. Each assistant is expected to co-operate with the State Geologist in answering inquiries concerning his field.

3rd. Requests from private individuals for analyses of minerals and ores, and tests to establish their commercial value.—Such requests are frequent. They cannot be granted, however, except in rare instances. Such work should be sent to a commercial chemical laboratory. The position has been taken that the Geological Survey is in no sense a chemical laboratory and testing station to which the people may turn for free analytical work. Whatever work of this sort is done, is done on the initiative of the Survey and not at the solicitation of an interested party.

The greatest misapprehension in the public mind regarding the Survey is on this point. Requests for State aid in determining the value of private mineral resources, ranging from an assay worth a dollar up to

drilling a test well costing several thousand dollars, represent extreme cases. At present there is no warrant for the Survey making private tests, even where the applicant is entirely willing to pay for the service. In many cases individuals would prefer the report of a State chemist or State geologist to that of any private expert, at equal cost, because of the prestige which such a report would carry. But it is a matter of doubt whether it will ever be the function of the Survey to enter into commercial work of this character; it certainly will not be unless explicit legal provisions for it are made.

4th. Requests from a number of persons representing a diversity of interests, who jointly ask the Survey to examine into and publicly report upon some matter of local public concern.—Such cases are not common. It is not always easy to determine whether such propositions are really actuated by public interest or not. Each case must be judged on its merits. The Survey will often be prevented from taking up such investigations by the lack of available funds, while otherwise the work would be attempted.

The reputed discovery of gold is one of the most prolific sources of such calls for State examination. It usually seems wise and proper to spend a small sum in preventing an unfounded rumor from gaining acceptance in the public mind, before it leads to large losses and unnecessary excitement. The duty of dispelling illusions of this sort cannot be considered an agreeable part of the work of the Survey, but it is nevertheless of very direct benefit to the people of the State.

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FOURTH SERIES, BULLETIN 13

THE MAXVILLE LIMESTONE

By WILLIAM CLIFFORD MORSE

November, 1910.

DR. J. A. BOWNOCKER,

State Geologist.

Dear Sir:—I submit herewith my report on the Maxville limestone. It represents a somewhat careful and rather detailed study of this important formation which is represented at too many places in our state by only a gap—hiatus—in the stratigraphic record.

Very truly yours,

W. C. MORSE.

Ohio State University,
Columbus, Ohio, November 23, 1910.

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ACKNOWLEDGMENTS.

The study of the Maxville limestone was undertaken as a thesis requirement for an advanced degree at the Ohio State University (granted in 1908) under the direction of Prof. Charles S. Prosser, and has been continued until the present time. The writer wishes to express his appreciation of an inspiring teacher and his thanks for the many suggestions and criticisms. A grant of fifty dollars was made by the Ohio Academy of Science to defray a part of the expense of the field work. This amount furnished a beginning, and the author takes this opportunity of expressing his sense of obligation to that organization, through the former chairman of the executive committee, Prof. William R. Lazenby. Dr. John A. Bownocker, State Geologist, also kindly allowed the expense and salary for a number of days of field work performed during the summer of 1909. Mr. James Morse of Hocking County, and Mr. Samuel Rarick of Perry, very generously furnished a horse and buggy for a number of weeks without charge to the Academy or to the state. To both of these and to a number of other friends the writer is under obligation.

CHAPTER I.

INTRODUCTION AND BIBLIOGRAPHY.

LOCATION.

AREAS OF OUTCROP.

The Maxville limestone appears at the surface in an interrupted series of outcrops in the southern half of the state of Ohio. More specifically, the series extends from Kents Run and Jonathan Creek, near Zanesville, southwest to the Kentucky side of the Ohio River, near Wheelersburg. Because of the interruptions, the region is naturally divisible into three parts—a northern, a central and a southern area. The northern area extends from Kents Run to Logan, and within it the Maxville is most fully developed. It also contains the best exposures, since the Zanesville & Western Railway cuts through the formation in a number of places along Jonathan Creek. The southern area extends from Hamden to the Ohio River. Only a few exceedingly small and isolated patches of Maxville are found in this area. The central area lies between Logan and Hamden, and so far as known contains no exposures.

AREA BENEATH THE SURFACE.

Besides the few wells near the line of outcrop in which the Maxville was encountered, there are a large number of wells far to the east of this line in which the limestone is also found. These wells are located principally in Monroe and Washington counties, in the southeastern part of the state. So universally present is the limestone in this region that it has become an important horizon marker for the oil drillers.

EXPLORATION.

PREVIOUS FIELD WORK.

Practically all of the field work upon the Maxville limestone was done in the years 1869 and 1870. It was performed by Prof. E. B. Andrews, while engaged in the study of the rocks of the second district, which comprised nearly the whole of the twenty-three counties lying southeast of Columbus. Considering the large extent of the district and the limited time of study, the work was most accurately done, and Andrews will ever receive credit for discovering, naming and correctly determining the geologic position of the stratum.

PRESENT FIELD WORK.

The present study of the stratum was begun during the spring of 1906, and has been continued intermittently until the present time.

Days and weeks of consecutive work have been spent in the field. However, during most of this period only such time has been available for study as was not required for regular duties.

In the northern area all of the known exposures have been carefully studied and sections made of them. Within the central area the line of contact between the Waverly and Pennsylvanian has been crossed and recrossed time and time again in the hope of finding an exposure of the limestone, but in vain. The few known exposures within the southern area have been treated like those of the northern area.

In addition, the basal conglomerate—the Sharon— of the overlying Pennsylvanian series was studied in Licking and Summit counties. Blocks in the conglomerate were known to be fossiliferous, and were supposed to be of Maxville origin. In company with Professor Carney, these were studied and fossils collected in them in Licking County, and Professor Carney's own collection from the same locality was very kindly donated for study. A similar study was made in the Cuyahoga Gorge and at Boston Ledges in Summit County.

GEOLOGIC POSITION.

The Maxville limestone occurs at the top of the Mississippian series. It is underlain by the highest formation of the Waverly and overlain by the lowest formation of the Pennsylvanian series. Its position and relation to the other formations and members of the Carboniferous system is clearly shown in the following table:

Carboniferous system.	Pennsylvanian series.	Monongahela formation.		
		Conemaugh formation.		
		Allegheny formation.		
		Pottsville formation	Homewood sandstone.	
			Mercer limestones and coals.	
			Upper Massillon sandstone.	
			Wellston coal (No. 2).	
			Lower Massillon sandstone.	
			Sharon coal (No. 1).	
			Sharon conglomerate.	
	Mississippian series.	Maxville limestone.		
		Waverly.	Logan formation.	
			Black Hand formation.	
			Cuyahoga formation.	
			Sunbury shale.	
			Berea formation.	
			Bedford shale.	

BIBLIOGRAPHY AND ABSTRACT OF LITERATURE

The literature relating to the Maxville stratum is taken up chronologically in the following pages. The references come first. These are followed by either short quotations or brief abstracts, and the latter in turn often by the present writer's interpretations.

Practically all of this literature pertaining to the Maxville is based upon Andrews's report of the field work which he performed during the years 1869 and 1870. That the subject of the Maxville limestone should reappear in state and other publications from time to time without further field work and reports is due primarily to two factors. These are (1) the questioning of the stratigraphical assignment of Andrews, and (2) the short reviews of the "geological relations" by the chief geologists in the succeeding state reports.

Previous to Andrews's reports, however, some four or five references are made to a limetsone, which is believed to be the Maxville. These references are in the First and Second Annual State Reports, and appeared in the year 1838. The priority of these references necessitates their discussion first, although a presentation of Andrews's reports first would seem more appropriate.

1838.

Briggs, Jr., C. Report of. Geol. Surv. Ohio, First Ann. Rept., pp. 82, 83. 1838.

In this report the author states that: "At Reid's mill, ten miles from the former place (Jackson), is a sandy limestone, ten or twelve feet thick, which may belong to this stratum, although the question of its identity is not entirely settled. Here much of it is light colored and sandy, and unless closely examined would be passed by as sandstone (p. 82)."

Continuing, he says: "There remains to be mentioned another stratum of limestone, the relative position of which has not been determined. It occurs in the south or southwest part of Jackson County, on the land of John Canter. The whole stratum may be ten or twelve feet thick. The superior part is white, or nearly so, and is fissured in almost every direction. The lower part is subcrystalline, and, in some places, beautifully shaded with green and red (p. 83)."

Although in doubt as to the correct position of these limestones, he places them, at least tentatively, in the Coal Measures, for they, with others, are discussed under "Limestones" of the "Lower coal series." The Maxville occurs at both of these places, and the description fits it fairly well. For these reasons it is believed that these limestones and the Maxville are one and the same.

Briggs, Jr., C. Report of. Geol. Surv. Ohio, Second Ann. Rept., p. 135. 1838.

In the second report Briggs has, among others, a geological account of Hocking and Athens counties. In his description of the Coal Measure limestones he says: "The lowest stratum of limestone which was observed is in Hocking County, on Three Mile Run, Sec. 28, Green Township, a little more than a mile from the Hocking River and about three miles below Logan. It lies in layers from a few inches to a foot in thickness, the average depth of the stratum being from eight to nine feet. The upper portion, from three to four feet in thickness, is yellowish or buff colored, containing so much iron that it may perhaps be used as an iron ore. At any rate, the ferruginous matter will render it the more valuable for a flux. The lower layer is nearly white, and will make lime of a superior quality. It seems to be nearly pure carbonate of lime, and in places sub-crystalline and sufficiently compact to admit of a polish.

"* * * It can be seen to the best advantage in the southeast part of Perry County, at McCormick's Quarry, on Sec. 17, in the township before mentioned (Monday Creek). Here it is extensively quarried for the manufacture of lime. A new quarry has also been opened south of it on Sec. 20 (p. 135)."

The Maxville occurs at both of these places. At the former place nine feet and four inches are now exposed. At the latter it was formerly quite extensively burned for lime. It would seem that the limestone which Briggs described at both places is the Maxville.

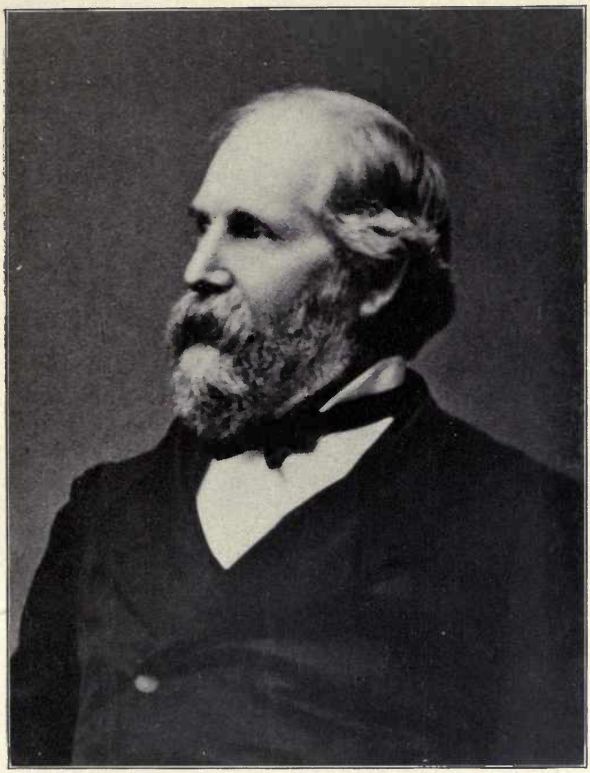
1870.

Andrews, E. B. Report of Progress in the Second District. Geol. Surv. Ohio, Rept. Prog. in 1869, pp. 80-86. 1870.

As has already been stated, Andrews named, described and determined the geological position of the Maxville limestone. He says: "There is above the Logan sandstone group a limestone horizon, although the limestone is not everywhere persistent. It often gives place to sandstone of the usual coal measure grit. It was evidently formed on local basins occupied by quiet waters and cut off from the reach of the strong, sand-moving currents. But as these limestones group themselves upon one geological horizon, and always rest upon the top of the Logan sandstone group, I have no doubt that they have the same geological age and were formed at the same time. I have called it the *Maxville limestone* from the village of that name in Monday Creek Township, in Perry County, eight or ten miles northeast of Logan, where it has been extensively burned into quicklime (p. 80)."

As a second place of occurrence, Andrews refers on the same page to the quarry on the land of James Tonnihill, Section 28, Green Township, Hocking County. This is undoubtedly the limestone which Briggs found on Three Mile Creek a mile from the Hocking River.

Nothing was known of the limestone in any direction from this



EBENEZER BALDWIN ANDREWS (1821-1880).

Professor of Natural Sciences at Marietta College from 1852 to 1869, and one of Ohio's leading geologists during the seventies.

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place, except to the north. "It appears continuously northward for half a mile, and then is said not to be seen until within two miles of Maxville." Andrews states further that "south and west of the Hocking River it has not been noticed; but from recollections of explorations made by me several years since between Jackson and the Ohio River, I am led to think that in a few places I saw small developments of this limestone in its true geological horizon. *The same horizon, continued across the Ohio River, would strike the Sub-carboniferous limestone of Kentucky.* I shall be able, next season, to settle this important point." In a footnote at the bottom of the page he says: "This has subsequently been verified, and the *Maxville limestone* will probably prove to be the equivalent of the *Chester limestone* of the Illinois Reports (pp. 80, 81)."

After commenting on the limited extent of the limestone at Maxville, Andrews refers to a third basin, which is much larger than the other two. "Following the horizon of the Maxville limestone north through Perry County," he says, "we find the stone finely exhibited in Section 16, Madison Township, Perry County, on the land of Edward Danison. Here the waters of Jonathan Creek have excavated a deep channel, and the limestone, with perhaps fifty feet of the Logan sandstone, is exposed to view. * * * The limestone is from this point often seen in the valley, and is well exposed at Newtonville (now called White Cottage), Newton Township, Muskingum County, where it lies in the bed of the stream. At Newtonville and in the vicinity a fine collection of fossils was made from the limestones, all indicating the Sub-carboniferous character of the rocks (p. 82)."

1871.

Andrews, E. B. Lower Carboniferous Limestone in Ohio. Am. Jour. Sci., Vol. 1, pp. 91, 92. 1871.

To further substantiate his position with reference to the age of the Maxville, Andrews writes: "For several years I have suspected that a certain limestone in southeastern Ohio should be classed with those of the Lower Carboniferous limestones. The supposition was entirely contrary to the 'traditions of the elders,' and furthermore, the limestone was *above* the principal range of conglomerate which has been ever regarded as true Coal Measure conglomerate. In the prosecution of the Ohio Geological Survey in the Second District, entrusted to me, I find the conglomerate referred to is a Waverly conglomerate; that it is separated from the base of the productive Coal Measures by an upper Waverly sandstone group, rich in fossils, which I have called the *Logan sandstone group*, and that resting upon this group is, in many places, a limestone, called the *Maxville limestone*, which is a true Lower Carboniferous limestone. * * * The stratigraphical position of the limestone and the contained fossils led me to suspect that we had in it an Ohio representative of the Chester limestone of the Illinois Reports. This opinion has been confirmed (p. 91)."

He then gives the following "List of species and genera," by Meek:

1. Zaphrentis spc.
2. Scaphiocrinus decadactylus Hall ?
3. Productus pileiformis McChesney
4. Productus elegans N. and P.
5. Chonetes spc.
6. Athyris subquadrata Hall
7. Athyris trinuclea Hall
8. Spirifer (Martinia) contractus M. and W.
9. Spirifer spc.
10. Terebratula spc.
11. Aviculopecten spc.
12. Allorisma spc.
13. Naticopsis spc.
14. Straparollus perspectivus Swallow, spc.
15. Bellerophon sublævis Hall
16. Pleurotomaria spc.
17. Nautilus spc.
18. Nautilus spc.

Quoting farther from Meek's letter, Andrews adds, in part: "Of the 18 or 20 species of fossils sent from this rock, about one-half are represented in the collection only by specimens that are too imperfect for specific identification, though none of them, so far as their characters can be made out, appear to be allied to known forms from any horizon below the St. Louis limestone."

"Of the remaining species, five can be identified confidently with Chester forms, and three others are either identical with Chester species or most closely allied to forms of that age. Hence we may safely say that eight of the species are *Chester types*. Two, however, seem to be identical with species described from the St. Louis limestone farther west (p. 92)."

Andrews, E. B. Report of Labors in the Second Geological District. Geol. Surv. Ohio, Rept. Prog. in 1870, pp. 60-66. 1871.

Andrews reports the occurrence of the Maxville limestone at a number of new places in this survey report, which appeared subsequently to the above article in the Journal. He says: "In addition to the locations of this limestone in my district, mentioned in my last report, it is found on the Zanesville and Maysville turnpike, near the west line of Perry County; at Reed's Mill, one mile northeast of Hamden, Vinton County; near Enoch Canter's, Section 24, Hamilton Township, Jackson County, and on the Harrison Furnace lands, Section 24, Clay Township, and Section 7, Harrison Township, Scioto County (p. 65)."

With reference to the origin of the Maxville, he says, on page 91 of the Journal: "This limestone is not a continuous deposit, but has only a local development here and there, always resting, however, upon the

fine-grained Logan sandstone group. It was deposited in quiet basins along a uniform horizon. Generally there is an iron ore adhering to the top of the limestone. There is no evidence that the local deposits were once continuous and united and were subsequently separated by erosion."

This was followed, shortly after, by the following statement on page 62 of the 1870 Report: "It is more than probable that the Logan deposits, and with them the Maxville limestones, which were doubtless formed in depressions in the Logan, were brought up above the water, and remained for an indefinite period as a vast stretch of sandy flats. It is possible that during this period more or less surface erosion took place, but to what extent my observations thus far do not furnish data for a definite answer."

With the conditions for erosion so fresh in mind, it seems strange that Andrews did not consider erosion at least as one of the possible causes why the Maxville is found in isolated patches. A careful study of the above statements will show, however, that he considers the deposition in isolated basins as sufficient to explain the conditions.

1873.

Newberry, J. S. Geological Relations of Ohio. Geol. Surv. Ohio, Vol. I, Pt. 1, p. 73. 1873.

Andrews, E. B. Report of Muskingum County. Pp. 314, 315, 317, 319, 320, 321, 328, 345, 346.

In this report nothing new about the Maxville limestone was brought out. Only a casual reference to it is made by Newberry. A few similar references occur in Andrews's report. However, Andrews does state the other side of this question as to the origin of the stratum in the following sentence: "Whether the thin beds of the Maxville limestone were deposited before this erosion took place, and so shared in it as now to be left in isolated patches, or were deposited at first in limited basins, is as yet undetermined (pp. 345, 346)."

Newberry, J. S. Descriptions of Fossil Fishes. Geol. Surv. Ohio, Vol. I, pt. II, pp. 282, 283. 1873.

This part of Vol. I was devoted to Paleontology. Among other things, it contains descriptions and figures of fossil fishes by Newberry. "Fishes of the Sub-Carboniferous Limestone" is the somewhat imposing subtitle of some two pages of general discussion. That the basis for the discussion was principally the happy anticipation of a true scientist may be judged from the closing paragraph. It reads: "The exposures of the Carboniferous (sub) limestone in Ohio are few, and they have never yet been carefully searched for fish remains. It is to be expected, however, that some fishes will be obtained from them, and these are likely

to be those found in the upper or Chester subdivision, the only portion of the great western limestone mass that is represented in our state (p. 283)."

1874.

Newberry, J. S. The Carboniferous System. Geol. Surv. Ohio, Vol. II, Pt. I, pp. 99-103. 1874.

In this report Newberry devotes a few pages to the "Lower Carboniferous Limestone." In these he copies Meek's list of Maxville fossils, to which previous reference has been made. He seeks to qualify one of Meek's statements, but this seems unnecessary, since Newberry evidently misinterpreted the statement. A few general remarks are also made about conditions under which the "Lower Carboniferous" rocks of Ohio and adjacent states were laid down.

1875.

Andrews, E. B. Descriptions of Fossil Plants from the Coal Measures of Ohio. Geol. Surv. Ohio, Vol. II, Pt. II, pp. 415, 416. 1875

Only two casual references are made to the Maxville limestone. Although confined to two sentences, they are sufficient for Andrews to drive home his belief that the Maxville is the Ohio equivalent of the Chester limestone.

1878.

Read, M. C. Report on the Geology of the Hocking Valley Coal-Field. Geol. Surv. Ohio, Vol. III, pp. 653-655, and 712. 1878.

Newberry, J. S. Review of the Geological Structure of Ohio. Geol. Surv. Ohio, Vol. III, pp. 23-25. 1878.

Orton, Edward. Supplemental Report on the Geology of the Hanging Rock District. Geol. Surv. Ohio, Vol. III, pp. 883, 888, op. p. 889, pp. 889-891, op. p. 912, pp. 921, 933. 1878.

Andrews, E. B. Supplemental Report on Perry County, and Portions of Hocking and Athens Counties. Geol. Surv. Ohio, Vol. III, pp. 817-824. 1878.

In this volume the Maxville limestone receives more than the usual amount of attention. Read gives a "Section of Rocks about Shawnee," in which the Maxville is shown at its proper horizon. Some three or four references are subsequently made to the formation, and in each case it is mentioned as occurring to the west, in the vicinity of Webb's Summit and Maxville. The important references occur, however, in the controversy between Orton and Newberry on the one hand and Andrews on the other. Since the stratigraphical position which Andrews assigned to the Maxville and adjacent rocks was questioned by both of the other men, the discussion will be given somewhat in detail.

Newberry, in his "Review of Geological Structure," states that: "Prof. Edward Orton, who has been engaged during the past summer in a careful review of the geology of the Hocking Valley region, has brought out some new facts in regard to the Maxwell limestone which will give it fresh interest to geologists, while at the same time they explain

in an unexpected way all the mysteries that have hung around it. These facts are briefly as follows: 1. That the Maxville limestone can be followed by numerous outcrops as a distinct geological horizon from Perry County to the Ohio River, and that it does not lie in patches alternating with others of conglomerate, as has been represented. 2. That one, sometimes two, limestones or flints are found within a hundred feet below it, which share in a degree its lithological character and fossils. 3. That the Wellston and Jackson coals, well known and important seams in southern Ohio, are both beneath the Maxville limestone.

"A recent visit to the Hocking Valley, in company with Prof. Orton, has resulted in the verification of all his observations, and the collection of fossils from the Maxville limestone and Waverly shales, which prove beyond question that the lower coals, two or three in number, of southern Ohio are of Lower Carboniferous age.

"Another important result of the recent observations of Prof. Orton is to demonstrate that all the conglomerate of southern Ohio lies below the Maxville limestone, and is therefore distinct from and older than the conglomerate of northern Ohio. The latter conclusion, which will, perhaps, be questioned, is established by the facts that the conglomerate of southern Ohio is overlain by shales, which contain the fossils characteristic of the Upper Waverly in Holmes, Summit, Mahoning, etc.; while the conglomerate of northern Ohio—which, apparently, extends no further south than Licking County, and thence thickens greatly northward—lies upon the Upper Waverly, and has no Waverly fossils in or above it (pp. 24, 25)."

These statements seem to be just a trifle more sweeping than those in Orton's letter, which accompanied the latter's report to the Chief Geologist, Newberry. In this letter Orton gives the following conclusions:

"1. The conglomerate of Pike and Jackson counties, which holds within it workable coal, is the conglomerate (Black Hand) of the Hocking Valley, which has been proved to be of Sub-carboniferous age. There are several divisions of this Conglomerate, but they are all included within two hundred feet of vertical range, and they all belong to one main series.

"2. The Jackson Shaft Coal belongs within the limits of this conglomerate, and is therefore of Sub-carboniferous age. The same thing is probably true of several other workable coal seams of the district.

"3. The Maxville limestone does not constitute the base of the Coal Measures of southern Ohio, but its place is from fifty to one hundred feet above the lowest coal seams. The Sub-carboniferous age of the limestone is not hereby questioned, but the same age is asserted for the lowest Coal Measures of this district (p. 883)."

In the report proper Orton says: "The horizon of the Maxville limestone can apparently be followed in patches of gray or drab, some-

times bluish, limestones, generally sandy in composition, from the south line of Vinton County, through the townships of Lick, Franklin and Hamilton, of Jackson County, and through Harrison and (————) townships, (of) Scioto County, to the Ohio River. In other words, the Maxville limestone constitutes a definite horizon in the Lower Coal Measures. It may be described as an *intra-conglomerate* limestone. The main body of the conglomerate, the Waverly conglomerate of Prof. Andrews, lies below it, but in the southern part of the district it is also overlain in some instances by twenty or thirty feet of conglomerate (p. 891)."

From this it is seen that Orton's published claims of the distribution of the Maxville limestone are not so great as Newberry reported above. The northern limit is Vinton instead of Perry County, while the southern is the same in either case. To what limestone in Lick and Franklin townships, Jackson County, Orton referred, is not known, but it must have been one of the limestones belonging to the Pennsylvanian series.

A chart of the "Coal Seams of the Hanging Rock District" is given in which the position of the limestones is also shown (op. p. 912). Another chart, "General Section, Showing Order of Succession of Coals, Ores and Limestones in the Hanging Rock District," as its name indicates, shows all of the rocks (op. p. 921). In both charts the Maxville is placed above the Jackson Shaft and Wellston coals. "Combined Sections from Vicinity of Hamden Junction, Vinton County, by Dr. L. W. Baker," is the title of still another chart published by Orton in this same report (op. p. 933). All of the strata are given in this section. The Maxville limestone is shown well up in the Pennsylvanian series with two or three coals below.

In this report Andrews firmly defends the position and age assigned to the Maxville limestone. He says: "The Maxville limestone rests upon the Waverly, and its deposition marked a new era in geological history. It is no part of the Waverly series, and has nothing in common with the Productive Coal Measures. As the last statement has recently been questioned by my associate, President Orton, who has expressed to me and to others his strong belief that the Maxville limestone is one of the regular Coal Measure limestones, having its true place about one hundred feet above the base of the Coal Measures, I shall be expected to give the reasons for the conclusions reached during the progress of the Survey and which I firmly hold (p. 817)."

After the seven places of occurrence are mentioned, the limestone is briefly described at each one. When the rocks are shown above and below, attention is always called to this fact and that these are the "Coal Measures" and Logan respectively. The "Lower Carboniferous" position of the Maxville is thus clearly shown.

Near the close of the discussion Andrews states that: "In the report for 1869 it was suggested that these areas of Maxville limestone may

represent local basins in which the limestone was deposited. This may have been wrong, for it is quite possible that in the original deposition the areas were connected and the formation continuous. After deposition, large areas of it might have been removed with much of the Waverly before the beds of the Coal Measure rocks were laid down. This would leave valleys between the remnants of the Maxville limestone series. The subject of the erosion of the Waverly and consequent uneven character of the floor on which the Coal Measures rest, has often been referred to in the Ohio Reports, and by different persons. In the report of Holmes County, in the present volume, Mr. M. C. Read gives, on page 544, an interesting illustration of this. Waverly rocks, capped with Conglomerate, are seen on one side of a hill, while on the other there are one hundred and ninety-eight feet of Coal Measures, including five seams of coal. There was evidently an ancient valley in the old Waverly in which the Coal Measures were formed. Proofs of similar valleys in regions adjacent to deposits of the Maxville limestone were long since observed. Of course the levels of the coals in them, if continued, would pass below the level of the limestone; *but in no case have any rocks of the true Coal Measures been found directly underneath any of the limestone of the Maxville series*, and I do not believe that such a case is possible (pp. 821, 822)."

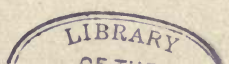
In the above paragraph Andrews admits that his idea that "the areas of Maxville limestone may represent local basins in which the limestone was deposited," may have been wrong. To take its place, he suggests the possibility of an original continuous deposit, later separated by erosion. The latter hypothesis is not proven, for the instances of erosion cited could have taken place as well before the Maxville age as after it. The statement only shows his readiness to accept proof that the separate patches are due to erosion. The uppermost thought in his mind was to prove that although there were coals below the *level* of the Maxville limestone, yet none occurred underneath it, as Orton so unfortunately claimed.

1879.

Andrews, E. B. Discovery of a New Group of Lower Carboniferous Rocks in Southeastern Ohio. Am. Jour. Sci., Vol. XVIII, p. 137. 1879.

Andrews reports the discovery in Perry County of a group of fossiliferous rocks between the Maxville limestone and the Waverly. From the fauna it is inferred that the group is approximately the equivalent of the Keokuk in age. The exact place of occurrence is not given, but, since the term Rushville was proposed for the group, the exposure is probably near the town of that name. A section is shown in which the Maxville limestone occurs at the top and is estimated to be from 15 to 18 feet in thickness.

Newberry, J. S., Chief Geologist; Andrews, E. B.; Orton, Edward; Read, M. C.; Gilbert, G. K.; Winchell, N. H., and Hill, F. C., Assistant Geologists. Geological Map of the State of Ohio. Geol. Surv. Ohio. 1879.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With the exception of a small area at Zanesville, the Lower Carboniferous limestone horizon is shown on this map as extending continuously from Dresden to the Ohio River.

Geological Atlas of the State of Ohio (Review). Am. Jour. Sci., Vol XVIII, p. 410, 1879.

From the following quotation it will be seen that Andrews objected rather strenuously to the Maxville limestone appearing as a continuous formation on a map a part of the work of which was credited to him. "Some points in the details of the part of the map relating to the section of the state under the charge of Professor E. B. Andrews are not in accordance with his conclusions; and since he had no part personally, as he states, in the preparation of the map, his proposed corrections, recently received for this Journal, are here annexed (Newberry, p. 410).

"(1) The Lower Carboniferous limestone—the Maxville limestone of my reports—is represented on the map as having a continuous outcrop, forming, with but a single short break, a continuous belt more than four hundred miles long around the sinuous margin of the Coal Measures. In my investigations in this district, where I have long lived, I have found the Lower Carboniferous limestone only in a few localities mentioned in the Reports, and always in limited patches. The limestone belt of the map crosses the paths of Professor Orton in Pike County, Professor M. C. Read in Licking County and Professor Stevenson in Muskingum (northern), but none of these field-workers saw it, and their detailed geological sections give no hint of it. (2) The Conglomerate at the base of the Coal Measures reported by Professor Orton in Pike County and by myself in Jackson County is omitted from the map (Andrews, p. 410)."

1880.

Orton, Edward. Review of Certain Points in the Geology of Eastern Ohio. Ann. Rept. Sec'y State for 1879, pp. 612, 613. 1880.

In this report the Maxville limestone is made a member of a group which consists of limestone, flint, fire-clay, coal and other "Coal Measure" rocks. After referring to his statements about the Maxville limestone in Volume III, Orton says: "I have never discussed this formation formally, but I am obliged to confess that in what I have said of it incidentally, and in what I have represented in sections accompanying my reports, I have incorporated several considerable errors. I regret these errors all the more because my friends have been, in some instances, misled by them in publications that they have made. I refer especially to Prof. Newberry's statements in Vol. III, Geol. of Ohio. The errors to which I refer consist in placing the Wellston coal below the Maxville limestone and the Jackson coal 100 feet below the same horizon. I am now satisfied that the Wellston coal belongs above the Maxville group,

and the conglomerate as well, and I am not sure that the Jackson coal lies below (pp. 612, 613)."

1882.

Whitfield, R. P. Descriptions of New Species of Fossils from Ohio, with Remarks on Some of the Geological Formations in Which They Occur. Annals New York Acad. Sci., Vol. II, pp. 219-226. 1882.

The fossils described in this paper were not illustrated, but each species was referred to a certain figure and plate in Volume III of the Paleontology of Ohio. This volume was to appear later, and in it the original descriptions were to be reprinted. The volume was, however, never printed.

The new species included eleven from the Maxville limestone, the "equivalent to the Chester limestone or Chester and St. Louis limestones." They are:

1. Cyathocrinus inequidactylus
2. Synocladia rectistyla
3. Pinna maxvillensis
4. Allorisma andrewsi
5. Allorisma maxvillensis
6. Naticopsis zic-zac
7. Holopea newtonensis
8. Macrocheilus subcorpulentus
9. Polyphemopsis melanoides
10. Bellerophon alternodosus
11. Nautilus pauper.

1884.

Orton, Edward. The Stratigraphical Order of the Lower Coal Measures of Ohio. Geol. Surv. Ohio, Vol. V, p. 99, 117. 1884.

Orton, in this report, gives a section of Jonathan Creek, in which the Maxville limestone is placed at the base of the section and below the "Coal Measures." The stratum is also referred to the Sub-carboniferous horizon (p. 99). Later in the report he says: "The stratigraphical order of the Hanging Rock District was in the main clearly shown in my report upon that field in Volume III, Geology of Ohio. The general section there published has proved a true one for almost every portion of the series, and has become an accepted guide in the practical development of the region. An error of some magnitude, and very confusing to the true order, is, however, to be found in the position assigned to the Maxville limestone. This limestone is undoubtedly of Sub-carboniferous age, and is geologically below both the Wellston and Jackson coals, whereas the section reverses this true order. The view so strenuously maintained by Andrews in regard to this point was the true one (p. 117)."

Hawes, George W. Building Stones of Ohio. Geol. Surv. Ohio, Vol. V pp. 578, 137 (637). 1884.

In this report of Hawes it is not quite clear whether the author places the Maxville limestone within the limits of the Waverly or not (p. 578). If he intended so to do he has departed from the usual methods. He also refers to the fine Muskingum County court house, which was built of limestone from this formation quarried at Newtonville (p. 137 should be 637, p. 638).

Orton, Edward. The Coal Seams of the Lower Coal Measures of Ohio. Geol. Surv. Ohio, Vol. V, pp. 869, 885, 991, 1009 and 1010. 1884.

The author refers to the Newtonville limestone of Chester limestone age as occurring near Uniontown (Fultonham), Muskingum County (p. 869). The term "Newtonville" is simply a synonym that is sometimes used instead of the Maxville. A slight reference is also made to the Maxville under the subheading, "Coal Mines of Perry County" (p.885). Under the title "The Hocking Valley Coal Field," Orton says: "The horizon (Sharon) is well marked, even when the coal is wanting, the Maxville limestone (Sub-carboniferous) or its clay, ore or flint being often found at nearly the same level (p. 991)." For reasons which will be presented later in the stratigraphical division of the present paper, it is not best to speak of the Maxville group as consisting of clay, ore or flint as well as of limestone. These rocks other than the limestone belong to a distinct and later date.

Under "Mines of Jackson County," we are pleased to hear Orton say: "The several conglomerates that occur in this general field are in fact one source of the confusion that prevails as to the true order. The Waverly (Black Hand) conglomerate is in strong force within this district. There are, besides, the conglomerate below and the one above the Jackson Shaft coal. As has been abundantly proved, the Carboniferous Conglomerate can no longer be counted an undivided stratum, but it is rather a complex and much varied formation. There is no single stratum of pebble rock in the state that has any longer a right to be called 'the Conglomerate.' " "In my report upon the Hanging Rock District in 1877, Vol. III, page 885, a mischievous and confusing error appears in all of the sections involving this part of the scale. The Jackson Shaft coal and the Wellston coal are represented as lying below the Maxville limestone. The real order is given in the preceding statement (pp. 1009, 1010)."

1886.

Orton, Edward. The Geological Scale of Ohio. Geol. Surv. Ohio, Prelim. Rept. Petroleum and Inflammable Gas, pp. 17, 26. 1886.

In this report the "Sub-carboniferous" limestone is given at its proper horizon. Mention is also made of its occurrence under cover in many drillings in the Ohio Valley, without locating the wells.

1887.

Orton, Edward. The Geological Scale of Ohio. Geol. Surv. Ohio, Prelim. Rept. Petroleum and Inflammable Gas. Reprinted for the author, with a supplement by A. H. Smythe, pp. 26, 39. 1887.

As the title indicates, this is a reprint of the previous volume, with a supplement, in the latter of which the Maxville is not mentioned.

Herrick, C. L. A Sketch of the Geological History of Licking County. Bull. Sci. Lab. Denison Univ., Vol. II, pp. 14, 15. 1887.

The Maxville limestone is shown in a number of sections in a plate of "Grouped Sections from Granville to Newton." The presence of the stratum near water level from Newton to near Mt. Perry is also mentioned.

1888.

Orton, Edward. The Geology of Ohio Considered in Its Relations to Petroleum and Natural Gas. Geol. Surv. Ohio, Vol. VI, p. 3, op. p. 4, and p. 42. 1888.

The Maxville limestone is placed at its proper horizon in both the geological scale and in the vertical section. Speaking of the stratum, Orton says: "The limestone is found in outcrop in Scioto, Jackson, Hocking, Perry and Muskingum counties. It is reported in the well records of Steubenville, Brilliant, Macksburg and at several other points in the Ohio Valley (p. 42)."

Orton, Edward. The Berea Grit as a Source of Oil and Gas in Ohio. Geol. Surv. Ohio, Vol. VI, pp. 321, 327 and 405. 1888.

In the "general order" of the strata in the wells of the Macksburg oil-field (p. 321) the Maxville limestone is not shown, although it was mentioned above as occurring there. No record of the well at Brilliant is published. The record of the Jefferson Iron Works well at Steubenville shows a limestone fifty feet in thickness, which is referred to as the "Sub-carboniferous" limestone (p. 337). Speaking of the limestone which occurs in the Laughlin well at Martin's Ferry, Orton says: "The record can be interpreted with but little difficulty, the Sub-carboniferous limestone, which was found at a depth of 845 feet, proving a great help in this work of classification (p. 405)."

Orton, Edward. The Production of Lime in Ohio. Geol. Surv. Ohio, Vol. VI, p. 707. 1888.

The author refers to the variability in composition of the Maxville limestone. This undoubtedly is due to a great extent in comparing the

lower half of the stratum as exposed at one place with the upper half at another.

Herrick, C. L. The Geology of Licking County, Ohio; Part IV, The Subcarboniferous and Waverly Groups. Bull. Sci. Lab. Denison Univ., Vol. III, Pt. I, pp.20-23, 1888.

The author says: "The next link in the series connecting the coal measures and the Waverly is found in the so-called Maxville or Chester limestone. A considerable fauna will yet be restored to us by a sufficiently prolonged search in the limestones and shales of this series in Ohio, which is nearly 25 feet thick in the vicinity of Fultonham. Eleven species have been described from this horizon by Whitfield. The characteristic species which are everywhere abundant are *Productus parvus*, which, however, is often much larger than the type, and approaches P. semireticulatus in some characters, *Spirifer glaber*, *Athyris subtilita*; *Euomphalus planodorsatus and Bellerophon* sp., *Pleurotomaria chesterensis* (*?*), *Holopea newtonensis* (*?*), *Nautilus spectabilis*, *Ctenodonta* (*?*) sp., *Allorisma andrewsi* (Plate XIII, Fig. 12) and *Spirifer increbescens*, H. With regard to the last-mentioned species, it may be here noted that no difficulty exists in tracing this species to its successor in the coal measures (S. opimus), and to its probable progenitor in the St. Louis group (S. Keokuk var. Hall), this in turn to the Keokuk group. There are many hints of this sort which will occur to the attentive student of these successive faunae. A cup coral, Lophophyllum sp. (?) (see Plate XIII, Fig. 17), also occurs rarely (p. 20)."

The two references to Plate XIII of Volume III are incorrect. They should be to Plate XI; and since this plate was accidentally omitted from Volume III, they should be to Plate XI of Volume IV. The statement of the abundance of the characteristic species is also decidedly misleading.

In the description of *Nautilis* (*?*) *bisulcatus*, sp. n., Herrick says: "N. pauper, Whitfield may prove identical with our form, but it would not be suspected except from incidental similarities, and the fact that our form is derived from the same horizon at Fultonham (p. 21)."

In this description the reference to "Plate XI, Fig. 16" should also be to Volume IV instead of Volume III.

After giving a section from a point two or three miles west of Fultonham, Herrick says: "No unconformity could be detected between the shales forming here the base of the coal-measures and the reddish layers, which are undoubtedly Waverly and contain *Chonetes illinoisensis* and other characteristic fossils (p. 21)."

Later: "While conformity between the upper Waverly and lower Chester does not exclude the idea of a considerable interval of time between the fossiliferous bands of the two groups, it is apparent that in Licking County the Chester interval is unrepresented and that much of

the upper Waverly is generally absent, so that the white sandstone or conglomerate of the coal-measures lies unconformably on one or other of the Waverly beds and the upper surface of the Waverly itself has obviously suffered erosion. The amount of the erosion varied in different places, and where greatest is covered by coarse quartz pebbles of granitic origin mingled with coal-measure trees of large size. The suggestion of extensive erosion (has) been heretofore made, but absolute proof has been wanting. It is our privilege to complete the evidence and to point out in general the amount of loss thus incurred. It has been quite generally supposed that an elevation of the coast at the close of the Waverly period caused the recession of the water, and that the period occupied at the west by the deposition of some 550 feet of sediments was not a time of rock formation in central Ohio. The results of close study of the lowest coal-measure conglomerate has unexpectedly indicated the contrary. While engaged in collecting samples of the quartz pebbles forming the bulk of this conglomerate eight miles northeast of Newark, a large number of fragments of limestone were also broken out. These are angular, and, though very badly decomposed, show that they could not have been derived from a distance, as the quartz must have been in order to free itself so fully of the softer, including the country rock, and acquire its rounded form, and moreover, they contained a few fossils which can only be referred to the age of the Chester or St. Louis group. These conglomerates are full of the impressions of Lepidodendrids and Calamites, and seem to have been torn from their places by torrents which carried from the mountains to the north their freight of coarser and finer material, much of it being of a metamorphic and igneous nature. The Chester limestone must at that time have been more or less firmly consolidated, perhaps in the form of clods of limy clay, and has preserved identifiable remains to tell the story. Thus the same coarse conglomerate tells us that a mighty river flowed into the coal-measures ocean from a region to the north, exposing igneous and metamorphic (partly granitic) rock, that it flowed through a region covered by deposits of St. Louis or Chester age, thus showing that a large series supposed to be absent in this part of the state was simply obliterated by erosion (pp. 22, 23)."

Herrick's interpretation of erosion and consequent unconformity is probably correct. But that he should have overlooked the proof positive in the Fultonham region, and accepted the vaguer paleontological evidence, seems strange. Especially is this true when it is stated that more or less of the lime in the angular blocks of the Sharon conglomerate has been replaced by silica, and that the fossils are in such an extremely poor state of preservation that positive identification is practically impossible.

Herrick, C. L. Geology of Licking County. Ohio; Part IV, Waverly Group, Continued. Bull. Denison Univ., Vol. IV, Pt. I, p. 122, pl. XI. 1888.

Plate XI is the one that was accidental y omitted from Volume III. It contains the following figures of fossils from the Maxville stratum:

Fig. 11. Productus parvus. Chester limestone.
Fig. 12. Allorisma andrewsi. Chester limestone.
Fig. 14. Spirifer increbescens. Chester limestone.
Fig. 15. Spirifer glaber. Chester limestone.
Fig. 16. Nautilus bisulcatus. Her. Chester limestone.
Fig. 17. Lophophyllum sp Chester limestone.
Fig. 23. Spirifer increbescens. From limestone fragments in coal measure conglomerate in Licking County.

With the exception of the figure of *Nautilus bisulcatus*, the description of which appeared in Volume III, these figures are not accompanied by descriptions. As a result there is some uncertainty as to the correctness of at least some of the identifications. Weller has referred *Spirifer glaber* to *Martinia contracta*, and the writer *Spirifer increbescens* to *Spirifer keokuk*. Herrick himself admitted that *Nautilus bisulcatus* may prove identical with Whitfield's *Nautilus pauper*. It seems probable that *Productus parvus* and *Lophophyllum* sp. may also prove identical with *Productus cestriensis* and *Zaphrentis* sp., respectively.

1890.

Orton, Edward. Geological Scale and Geological Structure of Ohio. Geol. Surv. Ohio, First Ann. Rept. (3rd organization), op. p. 9, and pp. 42, 43. 1890.

The portion which treats of the Maxville limestone in this report was copied from a similar portion, op. p. 4 and 42, of Volume VI.

1891.

Whitfield, R. P. Species from the Maxville Limestone, the Equivalent of the St. Louis and Chester Limestones of the Mississippi Valley. Annals New York Acad. Sci., Vol. V, pp. 576-595 and pls. XIII and XIV. 1891.

Since Part II, Paleontology, of Volume III was not printed, as has already been stated, the new fossils described by Whitfield in 1882 failed to be illustrated. In this 1891 report, however, the descriptions of the eleven new forms from the Maxville are reprinted from the 1882 report and are accompanied by illustrations. To these eleven are added the descriptions and figures of all of the other known forms, even though they had already been so treated. This addition was:

Zaphrentis cliffordana
Pentremites elegans
Polypora varsouviensis ?
Streptorhynchus crassum
Productus elegans
Productus pileiformis
Spirifera (Martinia) contractus
Spirifera rockymontana ?

Athyris subquadrata
Terebratula turgida
Schizodus chesterensis
Straparollus similis
Bellerophon sublævis ?
Nautilus (Temnocheilus) spectabilis

1893.

Orton, Edward. Geological Scale and Geological Structure of Ohio. Geol. Surv. Ohio, Vol. VII, Pt. I, p. 4 op. p. 4, and pp. 35, 36. 1893.

This part (Part I) of Volume VII was later bound with Part II to form the complete volume of 1894. Since the description of the "Sub-carboniferous" or Maxville limestone in Part I is practically a copy of that which appeared in Volume VI, it is not necessary to discuss this description now or to refer to it again when Volume VII as a whole is abstracted.

1894.

Whitfield, R. P. Species from the Maxville Limestone, the Equivalent of the St. Louis and Chester Limestones of the Mississippi Valley. Geol. Surv. Ohio, Vol. VII, Pt. II, pp. 465-481, pls. IX, X. 1894.

These descriptions and illustrations of the Maxville limestone are exact copies of the ones that appeared in Volume V of the Annals of the New York Academy of Sciences.

1897.

Weller, Stuart. The Batesville Sandstone of Arkansas. Trans. N. Y. Acad. Sci., Vol. XVI, pp. 251-282 and pls.

In this report Weller describes a number of new species from the Batesville sandstone. From both the paleontologic and stratigraphic evidence he pronounces the Batesville and the Aux Vases (Cypress) sandstone to be definite equivalents, and he states that "The paleontologic evidence also points to the equivalence of the Batesville sandstone and the Maxville limestone of Ohio (p. 282)."

1902.

Martzolff, Clement L. History of Perry County, Ohio. Ward & Weiland, New Lexington, Ohio, pp. 5, 6, 18 and 19. 1902.

In this report Martzolff says: "At McCuneville the Sub-carboniferous limestone is one hundred and ten feet beneath the creek bed (pp. 5, 6)." Later he gives a "Section of Rock at McCuneville" (pp. 18, 19), the lower part of which is from a salt well and includes the Maxville limestone. The section is credited to the Ohio Geological Report, but to which one is not stated. His "List of Fossils from the Maxville Limestone" consists of eighteen species. The list agrees, in its entirety, with Meek's list, which Andrews published in Volume I of the American Journal of Science and in the 'Report of Progress' in 1870, and to both of which reference has already been made.

Stevenson, John J. Notes on the Mauch Chunk of Pennsylvania. Am. Geol., Vol. XXIX, pp. 242-249 1902.

In this paper Stevenson has shown that the names Vespertine and Umbral, which H. D. Rogers applied to the lower and upper halves of the Mississippian rocks in Pennsylvania, were rejected, and replaced by Pocono and Mauch Chunk, by Lesley; and that the Mauch Chunk consists of three zones, shales, limestones, and shales, in the northern portion of the state, whereas it consists of only two, limestones and the upper shales, in the southern part, and that the United States and Maryland surveys have applied the terms Greenbrier and Mauch Chunk, respectively, to the limestone and upper shales of the original Mauch Chunk. These changes are shown more clearly in the following table:

H. D. Rogers	Lesley	Northern Penn.	Southern Penn. and to the south	United States and Maryland Surveys
Umbral	Mauch Chunk	shales limestones shales	shales limestones (shales, wanting)	Mauch Chunk Greenbrier
Vespertine	Pocono			Pocono

The limestones (Greenbrier) are, furthermore, shown by Stevenson to be made up of a lower siliceous limestone which is barren of fossils and an upper limestone which is much purer and very fossiliferous. From a rather extensive collection of fossils from this upper limestone, which Stevenson sent to him, Weller was enabled to pronounce the fauna as practically identical with that of the Maxville of Ohio as described by Whitfield in Volume VII of the Ohio Reports.

1903.

Stevenson, John J. Lower Carboniferous of the Appalachian Basin. Bull. Geol. Soc. Am., Vol. XIV, pp. 15-96, 1903.

In this subsequent report Stevenson has made some radical changes from the original classification of the Mississippian rocks of the Appalachian basin. The greater portion of the Pocono shales have had their old name supplanted by the term Logan, which the author, in following Herrick and Orton, has so expanded that it includes in Ohio not only the Logan, but at least the Black Hand as well, a usage not sanctioned by the later workers. Tuscumbia is adopted to cover the lower portion, siliceous limestone, of the Greenbrier and the shales just beneath which form one of the three subdivisions of the original Mauch Chunk and which are found only in northern Pennsylvania. For the upper portion—that is, the purer, fossiliferous limestone—of the Greenbrier, the term Max-

ville is adopted. The name Mauch Chunk as used in the restricted sense is replaced by the term Shenango. These changes can also be shown more clearly in a table:

United States and Maryland Surveys	Stevenson
Mauch Chunk.....	Shenango
Greenbrier {pure .... siliceous shales}	Maxville Tuscumbia
Pocono	{Logan .....

Bownocker, John Adams. The Occurrence and Exploitation of Petroleum and Natural Gas in Ohio. Geol. Surv. Ohio, Bull. I. 1903.

In this report it is said that the Maxville limestone is known to the driller as the "Mountain lime" or "Big lime" (p. 24). Under one or the other of these names a limestone occurs in the well records at a number of different places. These will now be given.

Wells in which the Maxville is reported:

	Thickness in feet.	Page.
McConnellsville Fair Ground, Morgan County.....	44	145
Mead farm, Washington County.....	35	185
Hohman Pool, Ludlow Township, generalized, Washington County.....	50	188
Lucas Farm, Washington County	150 (?)	190
Germantown Pool, Liberty Township, generalized, Washington County.....	0–20	192
G. Carpenter Well No. 1, Monroe County	35	196
J. R. Diest farm, Monroe County	60	196, 197
George Keller farm, Monroe County	134	201
Graysville Pool, generalized, Monroe County	60–100	204
J. Dearth farm, Monroe County.....	60	205–206
G. W. Martin farm, Monroe County	67	208
Holtsclaw well, Monroe County	40	210
F. C. Newhart well, Monroe County	36	212, 213
Longshore farm, Muskingum County	40	267

1904.

Orton, Jr., Edward, and Peppel, S. V. The Lime Resources of Ohio Available for Portland Cement Manufacture. Geol. Surv. Ohio, Bull. 3, p. 90. 1904.

Orton and Peppel assign the Maxville limestone to a position at the base of the Coal Measures and just above the "Sub-carboniferous" without stating their reasons. In reference to its origin they say: "It appears to have been deposited in lakes or ponds of limited area." This

statement is also incorrect, since the fossils of the limestone are of marine origin. Its most southern exposure is given as two and a half miles below Logan, whereas it is found in Vinton, Jackson and Scioto counties.

1906.

Orton, Jr., Edward. The Composition of the Limestones of Ohio, with Special Reference to Their Fitness for Portland Cement Manufacture, Considered by Counties. Geol. Surv. Ohio, Bull. 4, op. p. 31. and pp. 79, 82, 85, 88, 92, 105, 113-115, 122 and 126. 1906.

This report is accompanied by a map showing the principal limestone formations of the state. The "area in which the Maxville limestone may be expected" covers a part of Licking, Muskingum, Perry and Hocking counties (op. p. 31).

Under the heading of "Hocking County," Orton corrects his former error, and refers the Maxville to the "Sub-carboniferous" rather than to the Coal Measures. Speaking of its irregularity, he says: "It seems to be eminently a pocket, or lake bed formation, as it can be found only here and there inside the area represented by its outermost deposits. When found, these different deposits manifest wide differences in composition, thickness and lithological structure, greater than would be apt to be the case in a continuous stratum in so short a distance (p. 79)." "Its southernmost known deposit" is again given as two and a half miles southeast of Logan. These statements in reference to the irregularity, difference in composition and southern limit of the stratum have already been discussed, and need no further comment save perhaps the one in reference to the differences in composition. This variability in composition is undoubtedly due in a great degree to the comparing of the limestone of one-half of the stratum at one place with that of the other half at another locality.

Under the title of "Jackson County," the author says: "The Maxville has never been found (p. 82)." This seems to be an oversight. It will be recalled that Andrews reported as early as 1871 the Maxville as occurring near Enoch Canter's, Hamilton Township.

In "Lawrence County" the Lower Mercer is given as the lowest limestone. He says: "This limestone, or the Maxville, was encountered at Olive Furnace in a bore hole two hundred feet beneath the surface. The core removed was almost white, exceedingly dense, and a very pure carbonate of lime. The thickness was reported about twelve feet (p. 85)."

Speaking of Bowling Green, Franklin and Hopewell townships in "Licking County," he says: "In this vicinity the Maxville limestone is due, and is reported to have been found and worked for road metal in 1832 and 1835 for construction of the National Road to Columbus. Whether these old quarries came into Licking County is not known, but in any case they are not believed to represent a thick or important ex-

tension of the Maxville field. Nothing can be found of this formation in the gorge of the Licking River, eight or nine miles north (p. 88)."

Discussing the formations of "Mahoning County," the author says: "The Pottsville formation forms the floor on the north; Coal No. 1, at the bottom of the coal measures, was found in pockets around Youngstown and exhausted long ago. * * * The Maxville is missing (p. 92)."

Under "Muskingum County" the author says: "Mr. A. J. Hoover, of the Fultonham Brick Company, has drilled through the stone in several places in search of an artesian water supply. He reports the stone as variable, being cut out in spots, and present in points only one hundred feet or so distant. The thickness at the points drilled was about forty-five feet (p. 105)."

Under "Perry County" the author gives a section and an analysis of the Maxville as found on the land of David Hendricks, near Maxville, and discusses its fitness for a cement stone (pp. 113, 114). Analyses of samples from Section 25, Reading Township, and from near Fultonham, are also given (p. 114). Farther on the author says: "It has been quarried here (Glenford) for furnace flux, and for road materials during the 1830's, while the Maysville Pike or National Road was being put through this section. These old workings were long since abandoned, and are now so filled up that samples could not be gotten (p. 115)."

Speaking of the limestones of "Scioto County," Orton says: "The Maxville, due at the bottom of the coal measures, is represented locally by a flint fire clay of great purity. This formation occurs in basins or pockets, just as the Maxville limestone is suspected of doing. The latter is sparingly represented, if at all, by nuggets or bowlders of limestone occurring imbedded in clayey strata (p. 122)." Andrews, it will be recalled, reported this limestone on the Harrison Furnace lands, where it was mined for furnace flux. Under the heading of "Stark County" the author says: "The horizon of No. 1 Coal at Massillon is not characterized by any development of the Maxville limestone stratum (p. 126)."

Orton, Jr., Edward, and Peppel, Samuel Vernon. The Composition, Physical Character and Uses of the Limestones of Ohio, Considered by Geological Formations. Geol. Surv. Ohio, Bull. 4, pp. 168-172. 1906.

As the title suggests, the previous information appearing under the separate county headings is here assembled under that of the respective formations. At the close of the discussion on "The Maxville Limestone" the following note appears: "Since writing the foregoing some points have been raised which render the classification of the Fultonham stone as of Maxville age somewhat less certain than it had been regarded previously. The question is one of interest to stratigraphical geologists primarily. No abatement need be made in the statements regard-

ing the quantity or character of this stone, but it is barely possible that as a result of the investigations which will now be given to it that it may be found to be wrongly named, and that it may be Mercer in age instead of Maxville (p. 172)."

The stratigraphical portion of the present paper shows that the Fultonham stone is undoubtedly of Maxville age.

SUMMARY.

As early as 1838 Briggs described a limestone at Reed's Mill ten miles from Jackson, on the land of John Canter in Jackson County, on Three Mile Run near Logan, and in southern Perry County, and referred it to the Coal Measures, but the limestone is undoubtedly the Maxville, and hence belongs to the Mississippian series.

Andrews, in 1870, was the first to name, describe, and correctly refer the Maxville limestone to the Mississippian series. He studied the stone at three places, at Maxville, on Three Mile Run, and on Jonathan Creek, noted its occurrence in isolated patches, and accounted for this isolation by attributing its origin to deposition in local basins.

In 1871 Andrews published Meek's list of fossils, which confirmed the former's belief in the Chester age of the Maxville, and mentioned the limestone as occurring at a number of new localities—namely, in western Perry County, at Reed's Mill, near Enoch Canter's in Jackson County, and on the Harrison Furnace Lands in Scioto County.

In 1873 Andrews was ready to say that: "Whether the thin beds of the Maxville limestone were deposited before this erosion took place, and so shared in it as now to be left in isolated patches, or were deposited at first in limited basins, is as yet undetermined"—the only point concerning the stratum about which he ever had occasion to change his mind, and one which he never determined.

The controversy between Orton and Newberry on the one hand and Andrews on the other led to the publication of the statements of their respective claims during 1878. Orton maintained that one or more beds of coal occur beneath the Maxville, and that the limestone constitutes a zone which can be followed from Vinton County to the Ohio River. Although this was an error, the field evidence was accepted by Newberry. Andrews, on the other hand, again showed the Subcarboniferous age of the Maxville, the Logan age of the subjacent rocks, and that although there were coals below the level of the Maxville, yet none occur underneath it.

The large geologic map of the state was published in 1879, and upon it the Maxville was shown as a continuous belt extending from Dresden to the Ohio River with the exception of a small break at Zanesville. Since this continuity was not in accord with Andrews's view, and since he had no part in the preparation of the map, he objected rather stren-

uously to his name appearing upon it as one of the assistant geologists, and called attention to the fact that the limestone belt crossed the paths of Orton in Pike County, Read in Licking, and Stevenson in Muskingum (northern), but that none of these men saw it.

In 1880 Orton somewhat modified his views in reference to the position to which he assigned the Maxville, and states that the Wellston coal belongs above the limestone, and that he is not sure that the Jackson coal lies below.

A copy of the Annals of the New York Academy of Science appeared in 1882, in which eleven new species of fossils from the Maxville limestone, "the equivalent to the Chester limestone or Chester and St. Louis limestones," were described by Whitfield. Each species was referred to a certain figure and plate in Volume III of the Paleontology of Ohio, but this volume was never printed.

In 1884 Orton unreservedly states that the Maxville "is geologically below both the Wellston and Jackson coals."

Orton refers a limestone that is found in a number of wells in southeastern Ohio to the Maxville, in the 1888 report, and speaks of the variability in composition of the stratum.

During this same year Herrick published a section of the rocks at a point two or three miles west of Fultonham, and admitted his inability to find evidences of an unconformity at any horizon between the Coal Measure rocks and the Waverly. From his study of the fossiliferous blocks in the base of the Sharon in Licking County he concludes that such an unconformity exists there, and that these blocks were derived from the Maxville (Chester) of that vicinity. His conclusions are probably correct, but they cannot be definitely proven since the fossils are so poorly preserved that specific identification is practically impossible.

Since the Ohio report in which the eleven new species of Maxville fossils were to be illustrated was not printed, these forms were illustrated and the descriptions reprinted in the Annals of the New York Academy of Science by Whitfield in 1891. The forms which were already known to science were redescribed and reillustrated, thus raising the total number in the formation to twenty-four species. The descriptions and illustrations of these twenty-four species were reprinted without change in Volume VII of the Ohio Reports, in 1894.

In 1897 Weller stated that the paleontologic evidence points to the equivalence of the Batesville sandstone and the Maxville limestone of Ohio, and in 1902 pronounced the Greenbrier limestone fauna as practically identical with that of the Maxville of Ohio as described by Whitfield.

Bownocker, in 1903, reported the presence of the Maxville limestone in a number of wells in Washington, Monroe, and portions of adjacent counties.

Edward Orton, Jr., and Peppel, in 1904, assigned the Maxville to a position at the base of the Coal Measures, spoke of it as having been

deposited in lakes or ponds of limited area, and gave its most southern exposure as two and one-half miles south of Logan.

In 1906 Orton refers the Maxville to the Sub-carboniferous rather than to the Coal Measures, and again names the same place as its southernmost known deposit. In the same report Orton and Peppel raise the question as to whether the Fultonham stone is not Mercer in age rather than Maxville.

CHAPTER II.

LOCATION AND DESCRIPTION OF EXPOSURES.

The northern extension of the Mississippian limestone outcrops in Ohio at a number of places from the Ohio River near Sciotoville to a point near Zanesville. These outcrops, as has already been stated, are naturally divisible into three areas: a northern area, a central area and a southern area. These areas will now be taken up separately.

THE NORTHERN AREA.

The Northern Area extends from a point just below Logan to a point about a mile beyond White Cottage. It includes parts of Licking, Muskingum, Perry and Hocking counties. Within this field the Maxville has its best development.

JONATHAN CREEK EXPOSURES.

Two of the main branches of Jonathan Creek rise in the southern part of Licking County, and flow south into Perry County. At Glenford they unite, and thence maintain an easterly course through parts of Perry and Muskingum counties to the Muskingum River below Zanesville. The walls of the valley gradually converge to a point one mile east of Mt. Perry where the stream enters a gorge. The gorge consists of intrenched meanders, and continues very narrow as far east as Fultonham (Uniontown). Here a tributary is received from the south and the valley widens abnormally. Beyond, the walls contract and then gradually widen out again.

This lower portion of Jonathan Creek is far within the limits of the Coal Measures, but the stream has cut sufficiently deep in many places to expose the upper part of the Maxville limestone, and in others to show even the whole of the stratum as well as the upper Logan, thus giving us a most beautiful example of an inlier of Maxville—outcrops of Maxville completely surrounded by younger rock. To maintain its course within this gorge from Mt. Perry to Fultonham, it was necessary for the Zanesville & Western Railway to make numerous cuts across the "points" and along the walls of the valley, and many of these cuts show nearly the entire thickness of the Maxville limestone. This series of cuts and the natural exposures make this one of the most important places for the study of the Maxville stratigraphy.

About one mile below Mt. Perry the Zanesville and Western Railway crosses from the south to the north side of Jonathan Creek and follows the north bank until Fultonham is reached. The above crossing is by means of a tall iron bridge, and for convenience it will be called the Mt. Perry Iron Bridge. The cuts will be numbered consecutively down stream from this bridge.

Some two hundred yards below the Mt. Perry Iron Bridge, is Cut No. 1, in which the Sharon member rests upon the uneven surface of the Logan formation. Half-way between the bridge and the cut is a small gully in which the Sharon rests not upon the Logan, but upon the Maxville. For these reasons three sections were made of the cut, one on the south side and two on the north, and one of the gully. These sections will now be given.

Section of the south side of Cut No. 1.

	Ft.	In.	Ft.	In.
A^{10}—Soil	5	0		
Sharon member			13	11
A^{9}—Coarse-grained sandstone to fine conglomerate, friable, yellowish-brown, exceedingly cross-bedded	10	0		
A^{8}—Thin, bluish, argillaceous shales	1	0		
A^{7}—Yellowish-brown, nodular, sandstone layer, containing some iron and fossils	0	4		
A^{6}—Thin, bluish, argillaceous shale	1	0		
A^{5}—Irregular, brownish, coarse-grained sandstone with some iron and plant markings	0	10		
A^{4}—Friable, coarse-grained, shaly sandstone, interbedded with shaly coal	0	9±		
Disconformity.				
Logan formation			18	0
A^{3}—Thin bedded to shaly, bluish to buff sandstone, the upper part soft and yellowish	2	0		
A^{2}—Buff, argillaceous shales with a few thin layers of sandstone	2	3		
A^{1}—Thin bedded to shaly, fine-grained, bluish and buff sandstone to the Zanesville and Western Railway track level	13	9		

Opposite the place where the above section was made, the following complete and partial sections were measured.

Section of the north wall of Cut No. 1.

	Ft.	In.	Ft.	In.
B^{9}—Soil	5	6		
Sharon member			12	4
B^{8}—Coarse-grained sandstone to fine conglomerate, friable, brownish, ferruginous, and exceedingly cross-bedded	11	5		
B^{7}—Soft, coarsely arenaceous, bluish and brownish shale	0	10		
B^{6}—Black, carbonaceous shale. Coal horizon	0	1		

Disconformity.

	Ft.	In.	Ft.	In.
Logan formation			22	4
B^5—Thin-bedded, argillaceous sandstone	0	7		
B^4—Brownish, soft, argillaceous shales with thin sandstone partings	3	6		
B^3—Thin-bedded to shaly, bluish, argillaceous sandstone	2	9		
B^2—Buff, argillaceous shales, with a few thin layers of sandstone	2	3		
B^1—Thin-bedded to shaly, bluish and buff, argillaceous sandstone to the Zanesville & Western Railway track level	13	3.		

Five feet down stream from the above section the following partial section of the same wall was made. It includes only the Sharon and soil, and begins at the top of B^3.

Section (B) of the north wall of Cut No. 1.

	Ft.	In.	Ft.	In.
$(B)^7$—Soil	5	6		
Sharon member			16	7
$(B)^6$—Coarse-grained sandstone to fine conglomerate, friable, brownish, ferruginous, and exceedingly cross-bedded	13	5		
$(B)^5$—Argillaceous shale	0	1		
$(B)^4$—Inconstant, nodular layer of brown, ferruginous sandstone	0	4		
$(B)^3$—Friable, coarsely arenaceous, brownish shale	2	3		
$(B)^2$—Bluish-black clay or shale	0	3		
$(B)^1$—Bituminous, shaly coal	0	3		

Disconformity.

Top of B^3

A close comparison of these sections reveals some rather remarkable facts. Beneath the Sharon and above the track in Section B there are twenty-two feet and four inches of Logan, while in Section (B) there are only eighteen feet and three inches, and in Section A only eighteen feet. Although Section (B) is only five feet, and Section A but the width of the cut distant from Section B, the amount of Logan in the (B) and A sections is respectively four feet and one inch and four feet and four inches less than it is in Section B. In all sections the Logan beds are practically horizontal, and the upper line of contact of the formation cuts diagonally across layer after layer of sandstone and shale. Clearly then the Logan was raised above the sea, subjected to erosion, and then submerged some time between its deposition and the deposition of the Sharon. The line of contact between the Logan and

Sharon is, therefore, one of disconformity, or, in other words, an unconformity between parallel beds due to erosion. That this erosion which produced the surface within the Logan, and upon which the Sharon was laid down, was post-Maxville will now be shown.

About one hundred feet from these sections is the up stream end of the cut. Here, across the north wall of the cut, is a ditch in which numerous pieces of hard gray limestone were found. They contain *Productus pileiformis* and belong to the Maxville. From their shape they had evidently been subjected to erosion. Since they lie above the lowest part of the Sharon in the adjacent sections they must have been deposited and then worn away before the Sharon was laid down. Hence the erosion plain upon which the Sharon was deposited was formed in post-Maxville time.

Another important thing is the distribution of the thin zone of coal or carbonaceous matter at the base of the Sharon. This zone is practically continuous, and extends from the bottom of the depressions to the top of the elevations. That the coal could be deposited alike over the minor elevations and depressions shows that the waters of the transgressing sea were at first still and practically free from currents. This tranquillity lasted but for a short period, for the highly cross-bedded sandstone and conglomerate which appear above the coal are the results of swift and changing currents.

Were the few fragments of Maxville limestone which were found in the ditch the only evidence of its deposition and subsequent erosion the statements concerning post-Maxville erosion would be made with more reservation. About one hundred yards up stream from Cut No. 1 and below the Mt. Perry Iron Bridge, however, is a gully in which the Maxville is nicely exposed. For convenience the gully will be called the Bridge Gully, and a section of it will help corroborate the above conclusions.

Section of the Bridge Gully.

	Ft.	In.	Ft.	In.
Sharon member			5	1
C^{19}—Large blocks of micaceous sandstone which are in position farther up.				
C^{18}—Blue, micaceous, arenaceous shale	4	0		
C^{17}—Gray arenaceous shale resembling fire clay	0	8		
C^{16}—Red ferruginous layer with *Productus cestriensis*?	0	5		
Probable Disconformity.				
Maxville limestone			17	11
C^{15}—More massive limestone, which weathers to a yellowish mass	4	6		
C^{14}—Massive bluish and buff limestone, which weathers to a shale	2	5		

	Ft.	In.	Ft.	In.
C^{13}—Massive layer of rather pure gray limestone. *Productus cestriensis* Worthen	5	6		
C^{12}—Layer of pure, compact, gray, fossiliferous limestone. *Derbya crassa* Meek and Worthen	1	9		
C^{11}—Thin nodular layer of bluish limestone alternating with shales. It contains: 1. Zaphrentis cliffordana Milne-Edwards and Haime 2. Naticopsis ziczac Whitfield 3. Productus cestriensis Worthen	2	1		
C^{10}—Layer of bluish-gray pure limestone, containing: 1. Productus cestriensis Worthen 2. Seminula subquadrata Hall	1	1		
C^{9}—Dark or black shale	0	2		
C^{8}—Thin bluish limestone	0	1½		
C^{7}—Bluish impure limestone	0	4		
Logan formation			29	9
C^{6}—Bluish, argillaceous shale, with calcareous partings, which resemble those of the Waverly. Probably the top of Logan, but it cannot be stated definitely, since the rocks are covered for six feet below	0	8		
C^{5}—Covered, except for a few pieces of fossiliferous limestone, which may be in position	6	0		
C^{4}—Thin-bedded to shaly, argillaceous sandsandstone	3	0		
C^{3}—Bluish argillaceous shale, with some argillaceous sandstone layers	2	2		
C^{2}—Slightly covered. Mostly thin-bedded to shaly, bluish argillaceous sandstone	11	2		
C^{1}—Covered to the Zanesville and Western Railway track level, nine rail lengths (270 feet) from the previous sections	6	9		

The top of the Logan in the section just given is at least twenty-three feet and one inch and probably twenty-nine feet and nine inches above the track level. In either case it raises the base of the Maxville limestone above the base of the Sharon in Cut No. 1. It was impossible for the Maxville to have been deposited in higher places (i. e., in the gully and ditch where now found) without being deposited at the same time in the adjacent lower places (i. e., in Cut No. 1). The Maxville must, therefore, have been a continuous deposit, and it, with a part of the Logan, must have been subsequently removed from these basins in which the Sharon now rests upon the Logan.

Since the red ferruginous layer, C^{16}, in the Bridge Gully contains a fossil which is probably *Productus cestriensis* there is a strong in-

clination to refer the layer to the Maxville. Careful study at other and better exposures shows, however, that it is a continuous deposit very similar in its relations and distribution to the thin coal of the first section. It is, therefore, made the basal interval of the Sharon in this section.

The limestone in this region dips to the east or to the south of east. The rate of dip, while not perceptible, is even greater than the gradient of the stream. This brings the base of the Maxville nearer and nearer track and stream level as we progress in our study of the series of cuts. By the time Fultonham is reached the lower half of the limestone has passed beneath drainage. And, finally, at a point about two miles below White Cottage the whole disappears below the waters of Jonathan Creek.

About one-fourth of a mile below Cut No. 1 the railroad was compelled to cross another "point." This gives us Cut No. 2, in which quite an interval of the Maxville is exposed.

Section of the north wall of Cut No. 2.

	Ft.	In.	Ft.	In.
Maxville limestone			8	8
D^9—Top of exposure in ditch above cut. Poorly exposed, but apparently more massive, bluish-gray limestone without shaly partings	3	4		
D^8—Irregular and wavy-bedded, bluish, compact limestone in medium layers, which alternate with wavy shale intervals. Contains: 1. Dielasma turgida Hall	3	2		
D^7—Nodular, bluish, fossiliferous limestone	2	2		
Undetermined zone			2	4
D^6—Covered interval. It is not known whether this belongs to the Maxville or to the Logan				
Logan formation			18	8
D^5—Layer of blue, argillaceous sandstone, which, on weathering, breaks up into thin layers	0	9		
D^4—Blue argillaceous shales with an occasional sandstone parting	3	9		
D^3—Thin-bedded, blue argillaceous sandstones alternating with shales	2	3		
D^2—Blue argillaceous shales	1	8		
D^1—Thin to massive-bedded blue argillaceous sandstone, some of which are slightly cross-bedded. To track level	10	3		

Below Cut No. 2, in turn, is Cut No. 3, and in this cut the Maxville is beautifully shown.

Section of Cut No. 3.

	Ft.	In.	Ft.	In.
E^{14}—Top of cut. Soil	3	0		
Sharon member			5	3
E^{13}—Shales and talus	5	0		
E^{12}—Iron ore, the position of which is not clear	0	3		
Maxville limestone			13	4
E^{11}—Clay. About five feet away, however, is a five-inch block of limestone with iron ore clinging to its upper surface. The block occupies this horizon, but since it is slightly tilted, the top of the Maxville is not quite certain	0	5		
E^{10}—Massive bluish to pinkish limestone. Contains *Productus cestriensis* Worthen	4	0		
E^{9}—Massive layer of bluish to pinkish fossiliferous limestone	1	8		
E^{8}—Massive layer of blue and pink fossiliferous limestone	2	0		
E^{7}—Medium bedded to shaly limestone, which is argillaceous and varies in color from a pink to a buff. The fossils collected are: 1. Zaphrentis cliffordana Milne-Edwards and Haime 2. Productus cestriensis Worthen 3. Dielasma turgida Hall 4. Seminula subquadrata Hall	3	6		
E^{6}—Shaly, argillaceous, non-fossiliferous limestone. It probably consists of worked over sand and clay which were in turn mixed with calcareous material, and is probably also the base of the Maxville	1	9		
Logan formation			12	1
E^{5}—Bluish, impure limestone with a velvet-like luster, resembling calcareous layers of the Waverly farther south	1	4		
E^{4}—Buff, argillaceous shale	2	6		
E^{3}—Thin-bedded to shaly, argillaceous sandstone	2	9		
E^{2}—Buff, argillaceous shales, with thin, argillaceous sandstone partings	2	0		
E^{1}—Massive, buff, argillaceous sandstone, which is slightly cross-bedded and which breaks up into thin layers. To track level	3	6		

On account of the dip only one more cut shows the contact between the Logan and Maxville. This is Cut No. 4, which is located a fraction of a mile below the last one.

Section of Cut No. 4.

	Ft.	In.	Ft.	In.
F^8—Soil and talus from the Sharon. The top of the Maxville is not exposed.....	11	0		
Maxville limestone.....			15	7
F^7—Rather massive layer of limestone, the upper part of which has broken up into shale and all of which has weathered to a brownish buff. Among other fossils it contains:				
1. Productus cestriensis Worthen	5	6		
F^6—Nodular layers of gray, compact limestone with thin shaly partings. The limestone shows the stylolites structure. It contains:				
1. Productus pileiformis McChesney				
2. Productus cestriensis Worthen				
3. Spirifer keokuk Hall				
4. Cypricardella oblonga Hall				
5. Dentalium illinoiense Worthen				
6. Bulimorpha canaliculata Hall				
7. Bellerophon sublævis Hall				
8. Strophostylus carleyana Hall				
9. Murchisona vermicula Hall				
10. Nautilus pauper ? Whitfield..	0	11		
F^5—Layer of bluish-gray limestone somewhat purer than that below. The fossils are:				
1. Productus cestriensis Worthen				
2. Spirifer sp.				
3. Pelecypod shells.....	2	9		
F^4—Blue limestone without apparent bedding planes, but which becomes shaly, buff and arenaceous-like on weathering. The fossils are:				
1. Zaphrentis sp.				
2. Productus cestriensis Worthen				
3. Seminula subquadrata Hall				
4. Allorisma maxvillensis Whitfield				
5. Bellerophon sublævis ? Hall..	6	0		
F^3—Soft, bluish, argillaceous shale, which probably belongs to the base of the Maxville.....	0	5		
Logan formation.....			4	11
F^2—Layer of blue limestone with a velvet-like luster. It breaks up into pieces, and resembles similar layers of the Waverly.....	0	7		
F^1—Blue, argillaceous, shaly sandstone. with thicker partings and with an inconstant, nodular, calcareous layer near the top. To track level.....	4	4		

A.—A view of the Maxville limestone in Cut No. 4 between Mt. Perry and Fultonham, showing the impure lower portion and the basal contact on which Prof. Prosser stands.

B.—An exposure of the Maxville limestone in Jonathan Creek opposite the Fultonham Depot, showing the conspicuous stratification of the upper half, due in part to solution along the bedding planes and in part to the removal of the shaly partings.

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In the early study of this exposure (Cut No. 4) a collection of fossils was made from the stratum as a whole, and includes the following:

1. Bryozoan impression
2. Productus cestriensis Worthen
3. Spirifer keokuk Hall
4. Dielasma turgida ? Hall
5. Seminula subquadrata Hall
6. Bellerophon sublævis Hall
7. Orthonychia acutirostre Hall

Special attention should be called to

1. Cypricardella oblonga Hall
2. Dentalium illinoiense Worthen
3. Bulimorpha canaliculata Hall
4. Strophostylus carleyana Hall
5. Murchisona vermicula Hall
6. Orthonychia acutirostre Hall

which are new to the Maxville limestone. With the exception of *Dentalium illinoiense* this is a portion of the Spergen Hill (Salem limestone) fauna, which consists of a large number of mostly diminutive species of Gasteropoda, Pelecypoda and Brachiopoda and which reappears again in the Ste. Genevieve limestone and again in the Tribune limestone. Portions of these small Gasteropods, especially *Murchisona vermicula,* are very abundant in zone F^6 of this exposure.

Specimens of *Productus cestriensis* Worthen are frequently slightly crushed. Nevertheless they are robust forms, and, in this latter respect, they resemble specimens of the same species found in the lower half of the stratum farther to the south.

By referring to the last two sections, E and F of Cuts No. 3 and No. 4, it will be seen that the rocks at the top of the Logan rather blend into those at the base of the Maxville. The line of contact is not lithologically distinct and neither were there any fossils found in the limiting interval. It must be admitted then that the line of contact has been somewhat arbitrarily drawn. Since the Maxville is a limestone and the Logan a sandstone there is a strong temptation to extend the lower limits of the Maxville down one interval, in each section, and include the blue, impure limestone with a velvet-like luster. Examination of a large number of sections farther south has shown, however, that there is frequently to be found in the upper part of the Waverly one or more layers of blue, impure limestone with the same velvet-like luster. For this reason the impure limestone interval has been referred to the Logan.

The clayey and sandy nature of the lower five or six feet of the Maxville limestone is very interesting. As understood today this is taken to indicate a combination of environments. It suggests a com-

mingling of fairly deep and quiet sea conditions on the one hand and littoral or slightly off-shore on the other. To have such conditions presupposes a shore line migrating either landward or seaward.

Which of these movements we had in the case of the Maxville does not seem difficult to determine. Commencing at the base the Maxville becomes successively purer and purer as we ascend. This shows that the sea must have grown deeper and deeper and more and more quiet. Successively deeper and more quiet water is the product of a transgressing sea, of which the Maxville sea was a representative. The Maxville limestone and the Logan formation must, therefore, be considered as an illustration of transgressive overlap, as defined by Grabau [1].

From the few, only two or three, poor exposures of the Logan-Maxville contact already described, it is not possible to determine positively that the Maxville rests disconformably upon the Logan, although it will be shown to do so in the exposures to the south. But when all the phases of the subject are considered, it seems more than probable that the Logan was deposited beneath the sea, then raised to a land surface and subjected to the agents of weathering and erosion, before the deposition of the Maxville. As the Logan was over-ridden by the transgressing Maxville sea the unconsolidated residual sediments forming the top of the Logan were slightly worked over and mixed with the calcareous material forming the base of the Maxville.

Thus far it has been impossible to correlate any layer in a section with the same layer in another section. The sequence of deposition of the lower part of the Maxville seems to have been slightly different for each of the sections studied. Correlation is possible, however, in the sections which follow, at least those in this part of the Northern Area.

Section of Cut No. 5.

	Ft.	In.	Ft.	In.
Sharon member			13	3
G^{13}—Medium-bedded, coarse-grained sandstone	4	9		
G^{12}—Irregular, shaly to thin-bedded, coarse-grained sandstone	3	0		
G^{11}—Black, arenaceous and carbonaceous shales, with iron ore nodules	5	0		
G^{10}—Iron ore	0	4		
G^{9}—Gray shale	0	2		
Disconformity.				
Maxville limestone			23	7
G^{8}—Layer of dark bluish-gray limestone. Contains many Gasterpods at the top	1	6		

[1] Grabau, Amadeus W. Types of Sedimentary Overlap. *Bull. Geol. Soc. Am.*, Vol. XVII, pp. 570, 571.

	Ft.	In.	Ft.	In.
F^7—Shale-nodular zone. Nodular-like layers of limestone, alternating with shales. Both are very fossiliferous, containing:				
1. Productus cestriensis Worthen				
2. Dielasma turgida Hall				
3. Seminula subquadrata Hall				
4. Allorisma maxvillensis Whitfield				
5. Straporollus similis Meek and Worthen				
6. Bulimorpha melanoides Whitfield				
7. Naticopsis ziczac Whitfield.				
8. Bellerophon sublævis Hall...	3	3		
G^6—Reddish, argillaceous shales, with an occasional limestone parting.....	1	6		
G^5—Layer of bluish-gray compact limestone	0	4		
G^4—Massive layer of bluish, fossiliferous limestone, which weathers to a yellowish buff. On exposure the upper foot or foot and a half breaks into layers	8	4		
G^3—Massive layer of bluish limestone with an uneven base. The color changes to a buff when subjected to the elements. The fossils collected are:				
1. Productus cestriensis Worthen				
2. Spirifer sp.	4	10		
G^2—Nodular layers of bluish, compact limestone, with thin, shaly partings. Stylolites structure developed. Probably the equivalent of F^6. Contains:				
1. Productus cestriensis Worthen				
2. Bellerophon sublævis Hall				
3. Gasteropod shells, small.....	0	10		
G^1—Massive layer of bluish limestone which weathers to a buff color. The fossils are:				
1. Productus cestriensis Worthen				
2. Dielasma turgida Hall.				
To one and one-half feet below track level	3	0		

The nodular layers with thin shale partings which make up G^2 in Cut No. 5, are quite probably the equivalents of those of F^6 in Cut No. 4. In Cut No. 5 the equivalents of F^3 and F^4, then, would lie below track level. In other words, six feet and five inches of the base of the Maxville are covered beneath the lowest exposed layer, G^1, in Cut No. 5. If these two basal intervals be present in Cut No. 5, the total thickness of the Maxville, at this place, will then reach thirty feet, while the mas-

sive "lower zone" lying below the "shale nodular zone," G^7, will have a thickness of twenty-five feet and three inches.

Section of the upper end of Cut No. 6.

	Ft.	In.	Ft.	In.
Sharon member			11	6
H^8—Dark, arenaceous shales	11	0		
H^7—Iron ore	0	4		
H^6—In part. The upper one or two inches of this layer contain much iron, but it is firmly cemented to the remainder of the layer	0	2		
Disconformity.				
Maxville limestone			15	9
H^5—In part. Massive layer of bluish-gray fossiliferous limestone. It contains some rather small Gasteropod shells	1	1		
H^4—Three to four medium and slightly wavy layers of fossiliferous limestone with thin partings of shale	1	10		
H^3—Massive layer of dark, reddish-gray limestone. Gasteropods abundant	1	7		
H^2—Shale-nodular zone. Nodular-like layers of bluish limestone alternating with blue shale. The lowest layer of limestone is the thickest. Both the shales and the limestones are very fossiliferous, and are the equivalent of those grouped under G^7 in the last section. Among other fossils are: 1. Productus cestriensis Worthen 2. Seminula subquadrata Hall 3. Allorisma maxvillensis Whitfield 4. Naticopsis ziczac Whitfield 5. Bellerophon sublævis Hall	3	6		
H^1—Covered to track level	7	9		

That the nodular-like layers of bluish limestone which alternate with blue shales in G^7 (Cut No. 5) and H^2 (Cut No. 6) make up one and the same zone there seems to be no question. Both limestone and shale are exceedingly fossiliferous; far more so than any other horizon in the Maxville. *Productus cestriensis, Seminula subquadrata* and *Straparollus similis* literally fill the mass in places. The shales easily disintegrate, leaving the fossils free. After a rather large area of shales has been exposed for some time the fossils can actually be scooped up with a shovel. This fossiliferous zone is very striking when it is recalled that much of the Maxville is very sparingly fossiliferous, and in places practically barren.

A view of the Maxville limestone and the Sharon member in Cut No. 5, between Mt. Perry and Fultonham, showing most of the massive lower zone extending to the feet, the shale-nodular zone reaching to the hammer, and the upper zone here consisting of but one layer.

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Since reference will be made repeatedly to the above zone, G^7 and H^2, it will be called the *shale-nodular zone* for convenience. That portion below this zone will be called the *lower zone*. That above will be designated the *upper zone*.

Attention has already been called to the iron ore superimposed upon the limestone. Because of its importance, however, it will be necessary to refer to it a number of times. Frequently at least a part of the ore seems to form a part of the uppermost layer of limestone, and was, accordingly, at first included in the Maxville. Further study showed, however, that where the Maxville was eroded to a shale zone the ore is a distinct layer in itself, but when the erosion stopped on a limestone layer the ore is more or less cemented to the weathered surface of the limestone. In many places the erosion of the Maxville was succeeded by a deposition of the iron ore and the ore is, therefore, placed in the Pennsylvanian series.

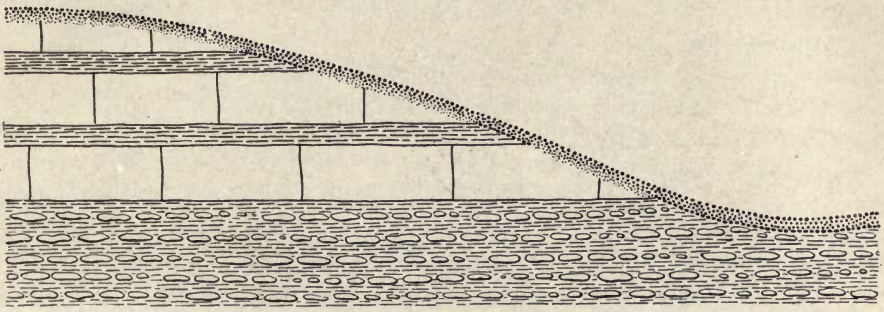

Fig 1.—A diagram of the uneven upper surface of the Maxville limestone and the iron ore in the base of the Pennsylvanian. Where the ore rests upon a layer of limestone it seemingly forms the top of the Maxville, but where it rests upon a zone of shale it clearly constitutes a distinct layer.

When the Section (G) of Cut No. 5 is compared with the Section (H) of the upper end of Cut No. 6 it will be seen that the Maxville has suffered more from erosion in the former than it has in the latter. The upper end of Cut No. 6 has two more intervals, H^4 and H^5, of limestone above the shale-nodular zone than has Cut No. 5. The denuding agents therefore penetrated three feet deeper in the vicinity of Cut No. 5 than they did at the upper end of Cut No. 6.

A nearer and therefore more striking example of unequal erosion is seen by passing down stream three rail lengths (90 feet) from where Section H was measured in the upper end of Cut No. 6. At this point the nineteen-inch layer designated H^3 has been reduced to eight inches in thickness. All of the superjacent layers have been swept away and the iron ore rests directly upon the layer which has been reduced to eight inches.

By carefully tracing the upper layer down stream in this, the upper end of Cut No. 6, it can actually be seen to be worn thinner and thinner until it finally disappears. The next lower layer can also be traced until it also finally disappears in a like manner, and so with other succeeding layers. Better proofs of unconformity, due to erosion, between the Maxville and the superjacent Pennsylvanian strata could not be desired and to the writer they are conclusive.

A short distance down stream from the last section and still within the same cut the following section was made:

Section of the middle of Cut No. 6.

	Ft.	In.	Ft.	In.
Sharon member			20	6
I^7—Black, soft, carbonaceous shale	1	0		
I^6—Dark gray, arenaceous shale	18	6		
I^5—Ferruginous shales and red iron ore	1	0		
Disconformity.				
Maxville limestone			11	0
I^4—Shale-nodular zone. Nodular-like layers of blue, compact limestone alternating with shales. The lowest layer is the thickest. Both limestones and shales are very fossiliferous. Among other fossils are: 1. Productus cestriensis Worthen 2. Seminula subquadrata Hall	1	7		
I^3—Reddish, argillaceous shales with two rather thick layers, one of which is blue and calcareous and the other red and ferruginous	2	7		
I^2—Bluish-gray, compact limestone, which is sparingly fossiliferous	0	10		
I^1—Massive layer of light colored limestone, the whole of which weathers to a buff and the upper part to thin layers. To one foot below track level	6	0		

Before this section was carefully studied and measured a collection of fossils was made from loose material in the face of the cut. It is probable that the majority, if not all of the specimens, came from the shale-nodular zone (I^4). The collection contains:

1. Productus cestriensis Worthen
2. Dielasma turgida Hall
3. Seminula subquadrata Hall
4. Allorisma andrewsi Whitfield
5. Allorisma maxvillensis Whitfield
6. Straparollus similis Meek and Worthen

7. Bulimorpha melanoides Whitfield
8. Sphærodoma subcorpulenta Whitfield
9. Naticopsis ziczac Whitfield
10. Bellerophon sublævis Hall
11. Trilobite unidentified.

This section, I, of the middle of Cut No. 6, is only twelve rail lengths (360 feet) down stream from the preceding section, H, of the upper end of Cut No. 6. The Maxville has suffered six feet and five inches more erosion here than at the preceding place. When the last three sections (G, H and I) are compared, the line of disconformity is seen to be low in the Maxville scale in Cut No. 5, somewhat higher in the upper end, and low again in the middle of Cut No. 6.

Just below Cut No. 6 a public highway crosses the Zanesville and Western Railway tracks and in turn Jonathan Creek by means of a high iron bridge. This bridge is known as the Wortman Bridge. Between it and the Mt. Perry Iron Bridge are to be found all of the sections so far described.

Between the Wortman Bridge and Fultonham not only are the railroad cuts insignificant or wanting, but the top of the Maxville has almost passed below track level. Study of the Maxville has to be confined almost exclusively, therefore, to the banks of the stream. About halfway between the above points and about opposite Trestle No. 41 is Hough Hollow. It is on the opposite side of Jonathan Creek from the one on which the railroad is located. Along the banks of the main stream and up the branch, the Maxville is nicely exposed, and above it the Pottsville formation. The following section, taken at this point, shows the strata only a short distance above the Maxville.

Section of the south bank of Jonathan Creek at the mouth of Hough Hollow.

	Ft.	In.	Ft.	In.
Sharon member			4	6
J^{13}—Irregular-bedded, dark, arenaceous shales and coarse sandstone	4	0		
J^{12}—Iron ore	0	6		
Maxville limestone			17	5
J^{11}—Mostly covered, except a few inches of limestone at the top, and these are exposed farther up the run	1	7		
J^{10}—Layer of bluish-gray, fossiliferous limestone	1	6		
J^{9}—Layer of limestone with a pinkish tinge	2	2		
J^{8}—Weathered space, probably formerly occupied by shales	0	3		
J^{7}—Layer of limestone of pinkish hue	1			
J^{6}—Layers of irregular-bedded pink limestone	2	3		

	Ft.	In.	Ft.	I...
J^6—Layer of dark bluish-gray, compact limestone	1	10		
J^4—Shale-nodular zone. Nodular-like layers of blue, compact limestone alternating with blue shale. The lowest layer of limestone is the thickest. Both limestone and shales are very fossiliferous. The following were noted:				
1. Productus cestriensis Worthen				
2. Dielasma turgida Hall				
3. Seminula subquadrata Hall				
4. Straparollus similis Meek and Worthen				
5. Bellerophon sublævis Hall ..	2	9		
J^3—Pink argillaceous shales with two or three calcareous partings. The interval is slightly covered	1	5		
J^2—Bluish, compact, pure limestone	0	9		
J^1—Covered, except for two or three inches of limestone at the top. To low water level in Jonathan Creek	1	6		

The point has now been reached where, by combining parts of several sections, the complete thickness of the Maxville can be, at least approximately, determined. By taking portions of the sections of Cuts No. 4 and No. 5 we have, already, obtained twenty-five feet and three inches as a thickness for the lower zone of the formation. If to this be added that portion of the section of Hough Hollow forming the shale-nodular zone (J^4) of two feet and nine inches, and the upper zone (J^5-J^{11}), of eleven feet, a total thickness of thirty-nine feet for the formation is the result.

Enough sections have now been given to justify some generalizations in regard to the character of the lower and upper zones of the limestone. If sections F to J of Cuts No. 4 to No. 6 and of Hough Hollow be carefully studied, the lower zone will be seen to be practically made up of massive layers of limestone. The bedding planes are not conspicuous, the stone weathers to a buff, and the bottom layers are clayey. The layers of the upper zone are, on the other hand, thin to medium-bedded. In the face of a cliff the stratification is the conspicuous feature. Solution along the bedding plane or removal of the thin partings of shale causes each layer to project independently. The layers are purer limestone than those belonging to the lower zone, and their color is usually a blue or bluish-gray rather than a buff. In other words, the lower and upper zones are very dissimilar and in this region should not be confused.

In some places, the upper part is covered or has been removed by

pre-Pottsville erosion, leaving only the lower part exposed. In other places, the upper part only is exposed, while in still others, parts of both halves are revealed. The dissimilarity of the two halves of the formation has just been discussed. When one part of the limestone at one place is compared with another part at another you should not, therefore, expect them to be similar, and yet it is this comparison of dissimilar parts that has caused some of the later writers to say that the Maxville shows wide differences in composition and stratification in short distances.

In the Hough Hollow exposure, the shale-nodular zone was three feet and eight inches above water level. At the upper end of Fultonham are the Zanesville and Western Railway coal chutes, where their locomotives are "coaled," and on the opposite bank from the chutes the base of the shale-nodular zone is at low water mark. Down stream, before the next exposure is reached, the zone has dipped below water level. Just below Fultonham, Buckeye Fork enters Jonathan Creek from the south. About one-eighth of a mile below the confluence and on the opposite side of the stream is quite an exposure of Maxville. The shale-nodular zone has remained beneath drainage to this point, but here a small anticline or deeper erosion brings it up to low water mark. If we continue down stream from here to White Cottage the shale-nodular zone is not found above water level again. Going up Kents Run about one mile from White Cottage, however, a covered wooden bridge is reached where the zone again rises to water level.

At the coal chutes, quite an area of the layer designated J^5, the first one above the shale-nodular zone, is exposed. It is rather abundantly and conspicuously jointed. So also is the layer that forms the bed of the creek opposite the Fultonham depot, and the two are probably one and the same layer. At the latter place there are thirteen feet of limestone exposed. If the bottom layer be correctly identified, then one foot and ten inches added for its (J^5) thickness, would give fourteen feet and ten inches for the upper zone. If to this measurement be added two feet nine inches and twenty-five feet three inches, respectively, for the supposed shale-nodular zone and lower zone, a total thickness of forty-two feet ten inches for the Maxville is obtained. This thickness agrees very closely with the forty-five feet found by the Fultonham Brick Company in their drill holes.[1]

The Zanesville and Western Railway crosses from the north to the south side of Jonathan Creek at the upper end of Fultonham. It maintains its course on the south side of the creek until a point beyond White Cottage is reached. Immediately below Fultonham it crosses

[1]Orton, Jr., Edward. The Composition of the Limestones of Ohio. *Geol. Surv. Ohio,* Bull. 4, p. 105.

Buckeye Fork, just before this stream empties into Jonathan Creek, by means of a low iron bridge.

From a point about one hundred yards above the upper bridge to a point a like distance below the lower bridge, the Maxville limestone makes up the floor and walls of the channel. The shale-nodular zone was seen to pass below water level just above the upper limit and remain beneath until just below the lower limit. The limestone exposed within this stretch, therefore, belongs to the upper half of the formation. It is a gray, compact stone made up of conspicuous medium layers. This latter feature is nicely shown in the following section which was taken just below the mouth of Buckeye Fork where Jonathan Creek has excavated a rather deep channel.

Section of the south bank of Jonathan Creek at the mouth of Buckeye Fork.

	Ft.	In.	Ft.	In.
Soil				
Maxville limestone			13	9
K^7—Thin-bedded, gray, compact, fossiliferous limestone. Contains:				
1. Pentremites sp.	6	6		
K^6—Layer of gray, compact, fossiliferous limestone. Contains, besides numerous specimens of small Brachiopods:				
1. Zaphrentis cliffordana ? Milne-Edwards and Haine				
2. Pentremites elegans Lyon	1	9		
K^5—Layer of bluish-gray, compact limestone. Among other fossils are:				
1. Martinia contracta Meek and Worthen (a)				
2. Spirifer rockymontanus ?Marcou				
3. Corals	1	8		
K^4—Layer of bluish-gray, compact limestone. Contains, among other fossils:				
1. Derbya crassa Meek and Worthen	1	3		
K^3—Layer of gray, compact, fossiliferous limestone	1	2		
K^2—Parting of soft shale	0	2		
K^1—Gray, compact, fossiliferous limestone layer, which forms a half of the bed of the stream. To water level	1	3		

A general collection from this place and from another exposure of the same zone still farther down stream, includes the following additional forms:

1. Cyathocrinus maxvillensis Whitfield
2. Asterozoan unidentified

3. Bryozoan unidentified
4. Productus pileiformis McChesney
5. Straparollus similis Meek and Worthen
6. Nautilus pauper ? Whitfield

The shale-nodular zone rises above water just down stream from this place, and therefore the lowest interval of this section probably extends almost to this zone. How near the highest interval is to the top of the formation is not known since there is a soil covering. By passing up Buckeye Fork for a short distance, however, the top of the limestone is reached, and the formation then forms the floor of the channel for about a half mile farther.

At the point, one-eighth of a mile below the confluence of Buckeye Fork and Jonathan Creek, where the shale-nodular zone is exposed, the upper zone of the Maxville reaches a thickness of twenty-one feet and six inches. This is the greatest thickness yet found for this division of the limestone. The shale-nodular zone is present. Granting that the lower half is present also and that both have the usual thickness of two feet nine inches and twenty-five feet three inches, respectively, the total thickness of the Maxville reaches forty-nine feet six inches. Since the section at this point was measured in detail, it brings out the stratification even more markedly than did the last section. Therefore it will be given.

Section of the north bank of Jonathan Creek one-eighth of a mile below the mouth of Buckeye Fork.

	Ft.	In.	Ft.	In.
Soil				
Maxville limestone			22	8
L^{23}—Thin-bedded, gray, fossiliferous limestone to top of exposure in a ditch	1	10		
L^{22}—Interval practically all covered	1	9		
L^{21}—Thin-bedded, gray, fossiliferous limestone	2	7		
L^{20}—Layer of compact, gray limestone, forming the top of bank	0	9		
L^{19}—Parting	0	4		
L^{18}—Layer of compact gray limestone	0	10		
L^{17}—Two layers of compact gray limestone with shaly and nodular partings	1	3		
L^{16}—Layer of compact gray limestone which may separate into two	1	6		
L^{15}—Two thin layers of gray limestone with thin partings	0	9		
L^{14}—Layer of compact gray limestone	0	7		
L^{13}—Shaly parting	0	1		
L^{12}—Layer of compact, gray, fossiliferous limestone which may break into several layers. Contains:				
Bellerophon sublævis Hall	1	2		

	Ft.	In.	Ft.	In.
L^{11}—Shaly parting	0	1		
L^{10}—Layer of compact gray limestone	0	11		
L^{9}—Shaly parting	0	1		
L^{8}—Layer of compact gray limestone	1	3		
L^{7}—Shaly parting, wavy	0	5		
L^{6}—Layer of compact gray limestone	1	5		
L^{5}—Shaly zone, frequently with a layer of nodules at the center	0	6		
L^{4}—Layer of compact gray limestone	0	6		
L^{3}—Shaly parting, wavy	0	1		
L^{2}—Thick layer of compact gray limestone, which contains some calcite and some fossils. The upper surface often breaks up into one or two extra layers	2	10		
L^{1}—Shale-nodular zone. Nodular layers alternating with shale, to low water level	1	2		

Between the last exposure and White Cottage the Maxville limestone is shown at only one or two places. Somewhat below the last exposure and on the opposite side of the stream is one of these, and some ten or fifteen feet are exposed. These belong to the upper part of the formation, and the disappearance of the shaly intervals allows the medium layers to project in the usual manner.

By the time White Cottage is reached the dip and pre-Pottsville erosion have been sufficient to bring the top of the stratum to almost water level. From the dam at the old Gladstone Mill to a point below the depot, these few upper feet of limestone form the bed of the stream. The upper contact is shown directly under the mill where the following section was measured:

Section at Gladstone Mill.

	Ft.	In.	Ft.	In.
Pottsville formation			0	11
M^{6}—Layer of micaceous, coarse-grained, brownish, iron-stained sandstone to the top of the exposure under the mill. Across the stream and above the Zanesville and Western Railway a number of feet of Pottsville shales are exposed	0	5		
M^{5}—Black, bituminous shale	0	4		
M^{4}—Iron ore, mostly adhering to the top of the limestone	0	2		
Maxville limestone			5	8
M^{3}—Four rather irregular and thin layers of limestone with thin shaly partings which weather out, leaving the layers projecting. Besides numerous small				

	Ft.	In.	Ft.	In.
Crinoid stems, it contains the following fossils:				
1. Productus cestriensis Worthen				
2. Martinia contracta Meek and Worthen				
3. Spirifer rockymontanus Marcou				
4. Derbya crassa ? Meek and Worthen				
5. Bulimorpha melanoides ? Whitfield	1	2		
M^2—Compact, pure gray limestone which separates into thin layers. Solution may take place along the bedding planes. Fossiliferous	3	3		
M^1—Layer of compact gray limestone, the upper three inches often separating into an extra layer. Base extending below water level	1	3		

A number of fossils were collected from a large, flat block of limestone at the mill. Although the block was loose it undoubtedly came from the upper five or six feet of the stratum as exposed at this place. The specimens came from a three-inch zone and include:

1. Zaphrentis cliffordana Milne-Edwards and Haime
2. Pentremites sp.
3. Dielasma turgida Hall
4. Spirifer rockymontanus Marcou
5. Seminula subquadrata Hall
6. Martinia contracta Meek and Worthen
7. Straparollus similis Meek and Worthen

A general collection from the upper five or six feet of the limestone as exposed between Gladstone Mill and the White Cottage Depot gave the following additional forms:

1. Productus pileiformis McChesney
2. Allorisma andrewsi Whitfield
3. Bellerophon sublævis Hall
4. Trilobite unidentified

In the fourth or fifth layer of limestone above the shale-nodular zone at Fultonham, *Martinia contracta* is rather abundant. At White Cottage this same Brachiopod is rather common. These are the only places known where this fossil occurs in considerable numbers.

KENTS RUN EXPOSURES.

At White Cottage Jonathan Creek receives the waters of Kents Run from the north. This stream rises in Muskingum County near the National Road, flows north, thence west, thence south across the road, and finally to the southeast. In the lower half of its course it is about parallel

with Jonathan Creek. The upper half of its course is through glaciated country and the valley is rather open. The lower half, on the other hand, flows through a non-glaciated region and the valley becomes a gorge over two hundred feet deep and surpasses that of Jonathan Creek. Before the coming of the Rural Free Delivery and the passing of the cross-roads postoffice, Opera Postoffice was located at the head of the gorge.

As the Maxville limestone is exposed, as an inlier, more or less of the way along Jonathan Creek from Mt. Perry Iron Bridge to White Cottage, so also is the stratum exposed along Kents Run from Opera to the same place. Corresponding exposures are also very similar in the two streams. Starting at Opera with only the lower zone, and this above drainage, the formation approaches nearer and nearer stream level and finally passes below the run before White Cottage is reached. The upper zone has also been removed until a covered bridge one mile above White Cottage is reached. From this point to White Cottage the upper zone of the stratum is above drainage. Above Opera the limestone is poorly exposed at intervals for at least a mile.

At Opera a covered bridge crosses Kents Run, and just below the bridge is a series of good exposures. A few sections of these will now be given in order to show the Maxville-Pottsville disconformity and the consequent variation in thickness of the limestone stratum.

Section of the west bank of Kents Run, one hundred yards below Opera Bridge.

	Ft.	In.	Ft.	In.
Soil				
Maxville limestone			5	6
A^8—Thick layer of buff argillaceous limestone	2	5		
A^7—Thin layer of limestone, usually with a shaly parting above and below	0	4 ±		
A^6—Layer of grayish or buff argillaceous limestone. Twelve feet downstream this layer was worn down to 10 inches, and three feet farther the whole of the limestone stratum was worn away, but reappears again	1	10		
A^5—Irregular, shaly parting. In places this becomes indurated, when the layer above and the one below are united	0	2 ±		
A^4—Irregular layer of buff or gray argillaceous limestone	0	9		
Logan formation			2	4
A^3—Black bituminous shale. The contact with the limestone above is slightly wavy	0	1		
A^2—Blue shaly sandstone	0	3		
A^1—Soft, argillaceous blue shale to water level	2	0		

Section twelve feet down stream from the last.

	Ft.	In.	Ft.	In.
Pottsville formation			5	3
B^8—Cross-bedded, coarse-grained brown sandstone to the top of the exposure	5	0		
B^7—Iron ore	0	3		
Disconformity.				
Maxville limestone			1	9
B^6—Layer of argillaceous buff limestone, the upper surface of which was eroded one foot in less than twelve feet	0	10		
B^5—Shaly parting	0	2 ±		
B^4—Irregular layer of argillaceous buff limestone	0	9		
Logan formation			1	11
B^3—Black bituminous shale. Contact with the limestone above slightly wavy	0	1		
B^2—Blue shaly sandstone	0	3		
B^1—Soft, argillaceous blue shale to water level at the same place	1	7		

These two sections reveal a beautiful example of disconformity. They show a difference of pre-Pottsville erosion in the upper surface of the Maxville limestone of at least three feet nine inches in a horizontal distance of twelve feet. The top layer of limestone (A^8) can actually be traced until it completely disappears, as can also the next lower interval (A^7). The third layer (A^6) of one foot ten inches is seen to diminish to a thickness of only ten inches in this same distance.

About three feet farther down stream the whole of the formation was probably worn away. This is true of the layers of limestone. But since the Sharon sandstone does not quite reach the dark shale, A^3 and B^3, of the Logan, but rests upon a few inches of shale or clay, it is not quite clear whether this clay or shale belongs to the Sharon or not. It seems more than probable, however, that it does.

A few feet farther down stream the limestone layers appear again,

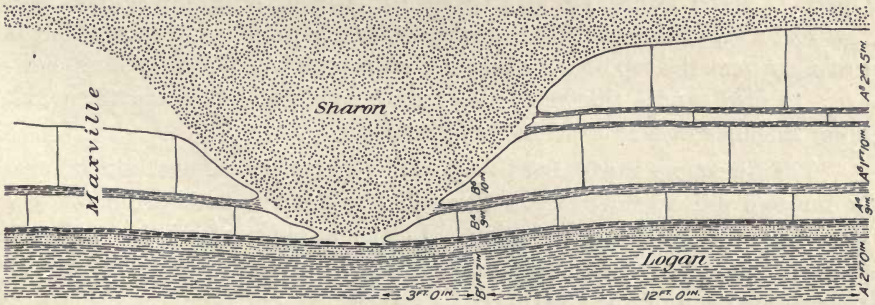

Fig. 2.—A "fossil" valley. A sketch of the south bank of Kents Run at Opera, showing a pre-Pottsville valley in the Maxville limestone filled with Sharon sandstone.

and the base of the Sharon is seen to rise. This then is a natural cross section of the walls (limestone) and filling (sandstone) of an ancient pre-Pottsville valley. It shows that the thickness of the limestone in the center of the old valley is practically zero while at the sides, fifteen feet away, it is at least five and one-half feet. Fig. 2 probably shows these features more clearly.

A few hundred yards below the Opera Covered Bridge an exposure shows the top and bottom contacts of the Maxville limestone. The following section was measured at this place:

Section of the west bank of Kents Run a few hundred yards below Opera Bridge.

	Ft.	In.	Ft.	In.
Pottsville formation			0	3
C^9—Iron ore, clinging in places to the top of the limestone. Covered above.				
Maxville limestone			13	0
C^8—Layer of harder and darker limestone	0	5		
C^7—Massive layer of buff, argillaceous limestone, which may break up into a number of layers and which shatters badly upon weathering	6	8		
C^6—Irregular shaly parting	0	1 ±		
C^5—Irregular layer of buff, argillaceous limestone, which may break up into other layers	2	10		
C^4—Irregular shaly parting	0	1 ±		
C^3—Layer of buff argillaceous limestone with an irregular upper bedding plane	2	11		
Logan formation			4	
C^2—Argillaceous to arenaceous, soft buff shales	1	0		
C^1—Interval covered to water level	3	3		

The Maxville limestone in this section is thirteen feet in thickness. At the forks of the highway, one or two hundred yards above the Opera Covered Bridge, is an exposure in which the lower contact is a few feet above the water, and in which the upper one is not shown, but is probably near the top of the exposure. The bank is sufficiently high, however, to also expose thirteen feet of limestone, and these are the maximum thicknesses measured in this vicinity.

The limestone is exposed in the banks of the run almost continuously for two miles below Opera Covered Bridge, but both contacts were not found below the last section. In the lower part of this distance the top contact reaches water level, and the water flows over the wavy iron stained top of the stratum.

About four miles above White Cottage and two miles below Opera Covered Bridge, is another covered bridge across Kents Run. At this

point, a small tributary is received from the north, and about a quarter of a mile up this branch two wells have been drilled for oil by the Kents Run and White Cottage Gas and Oil Co. One of these is on the Sales property and the other is twelve hundred feet farther up stream on the farm of Mr. Ford.

Mr. Dollinger of this company informs the writer that the well on the Sales property passed through fourteen to sixteen feet of Maxville limestone at twenty feet from the mouth of the well. The Ford well, twelve hundred feet above, on the other hand, penetrated no lime. Since the latter well is situated up stream from the other and in a narrow valley, it does not seem possible that recent erosion has removed the Maxville limestone at this place. The drill seems to have revealed in the one a pre-Pottsville valley similar to the one just described at Opera, and in the other the Maxville limestone of about the same thickness as at Opera.

About two miles above White Cottage and opposite the home of W. T. Wilkins, is an outcrop of Maxville limestone. This exposure is also the lower half, and is a massive limestone four to six feet in thickness without a bedding plane. In color the stone is brownish and in texture somewhat crystalline.

One mile above White Cottage is the third covered bridge across Kents Run below Opera, or the first above White Cottage. At this point is the residence of Ed. Kroft, and the bridge will be called the Kroft Bridge. In front of the house the following instructive section was made:

Section at the Kroft Residence.

	Ft.	In.	Ft.	In.
Maxville limestone			6	11
D^{10}—Layer of compact dove-colored limestone to top of exposure	0	6		
D^{9}—Shaly parting	0	1		
D^{8}—Layer of compact, dove-colored, fossiliferous limestone. This is probably the layer partly under water in the exposure at Mr. Thompson's	1	9		
D^{7}—Shaly parting	0	1		
D^{6}—Probable top of the shale-nodular zone. Layer of compact, dove-colored, fossiliferous limestone. Contains: 1. Productus cestriensis Worthen 2. Bellerophon sublævis Hall	0	6		
D^{5}—Calcareous shales alternating with thin nodular layers of limestone. Very fossilliferous, containing large numbers of: 1. Productus cestriensis Worthen 2. Seminula subquadrata Hall 3. Straparollus similis Meek and Worthen	1	3		

	Ft.	In.	Ft.	In.
D^4—Probable base of the shale-nodular zone. Layer of bluish, crystalline, fossiliferous limestone, nodular on top....	0	10		
D^3—Soft, argillaceous and calcareous dark shale	0	7		
D^2—Hard, calcareous shale to thin-bedded limestone, the material of the subjacent interval replacing the shales to some extent.....	0	10		
D^1—Blue, fine conglomeratic limestone, or limestone with minute calcareous concretions. Base of exposure under water	0	6?		

The important thing in this section is the presence of the shale-nodular zone, since this is the first place it is found, in descending Kents Run. Being so near water level the zone passes beneath drainage in a much less distance than it did in Jonathan Creek.

Just below the Kroft Bridge is another exposure. In this the shale-nodular zone occurs at water level and is overlain with a few layers of the upper half of the Maxville. These layers have been quarried to a slight extent, exposing quite an area of the shale-nodular zone in the bed of the stream. During high waters the looser material is washed away, leaving large numbers of fossils exposed to view. They are so abundant that those of the softer material can actually be scooped up with a shovel. This is the best collecting place known in the Maxville stratum. The different species found at this place are listed in the following section.

Section at the Kroft Bridge.

	Ft.	In.	Ft.	In.
Maxville limestone			4	10
E^6—Layer of compact, fossiliferous blue limestone to the top of the exposure at flood plain level.....	0	6		
E^5—Soft shaly interval, which weathers out, leaving a space between the sub- and superjacent layers	0	1		
E^4—Massive, compact blue limestone. Contains: 1. Bellerophon sublævis Hall...	2	5		
E^3—Soft shaly interval, which weathers away	0	2		
E^2—Probable top of the shale-nodular zone. Layer of compact blue limestone. Contains: 1. Bellerophon sublævis Hall...	0	8		
E^1—Shales alternating with nodular layers of blue limestone. Very fossiliferous. Containing: 1. Septopora rectistyla Whitfield 2. Fenestella serratula Ulrich 3. Productus cestriensis Worthen				

	Ft.	In.	Ft.	In.
4. Dielasma turgida Hall				
5. Seminula subquadrata Hall				
6. Pinna maxvillensis Whitfield				
7. Straparollus similis Meek and Worthen				
8. Holopea newtonensis Whitfield				
9. Bulimorpha melanoides Whitfield.				
10. Naticopsis ziczac Whitfield				
11. Bellerophon sublævis Hall				
12. Orthoceras randolphense Worthen				
13. Orthoceras okawense ? Worthen				
14. Trilobite unidentified. To water level.....	1	0		

While the exposures are not continuous down stream, yet it is apparent that the shale-nodular zone has dipped below water level before the good exposure of the north bank opposite the home of Mr. R. G. Thompson is reached. At this place a thick layer is seen under water and it seems more than probable that this is the first layer, D^8, above the shale-nodular zone. If it be not this layer it cannot be one far above this zone. The section follows:

Section at the Thompson Residence.

	Ft.	In.	Ft.	In.
Maxville limestone.....			12	8
F^{11}—Layer of gray limestone.....	1	6		
F^{10}—Layer of crystalline, fossiliferous reddish limestone. Contains:				
1. Bryozoan impression				
2. Productus pileiformis McChesney				
3. Productus cestriensis Worthen				
4. Martinia contracta Meek and Worthen				
5. Pinna maxvillensis Whitfield				
6. Allorisma andrewsi Whitfield				
7. Cephalopod unidentified.....	1	9		
F^9—Layer of fossiliferous, bluish-gray limestone. Contains:				
1. Bryozoan reverse side				
2. Productus pileiformis McChesney				
3. Productus cestriensis Worthen				
4. Martinia contracta Meek and Worthen				
5. Spirifer rockymontanus Marcou	2	0		

	Ft.	In.	Ft.	In.
F^8—Layer of fossiliferous, cherty gray limestone. Contains:				
1. Martinia contracta Meek and Worthen				
2. Dielasma turgida Hall				
3. Trilobite unidentified	0	10		
F^7—Layer of compact, fossiliferous bluish-gray limestone. Contains:				
1. Productus pileiformis McChesney				
2. Productus cestriensis Worthen				
3. Martinia contracta Meek and Worthen				
4. Dielasma turgida Hall				
5. Seminula subquadrata Hall				
6. Derbya crassa ? Meek and Worthen				
7. Bellerophon sublævis Hall				
8. Trilobite unidentified	1	0		
F^6—Layer of compact reddish-gray limestone	0	3		
F^5—Layer of fossiliferous, compact bluish-gray limestone. Contains:				
1. Productus pileiformis McChesney (A)				
2. Productus cestriensis Worthen (C)				
3. Martinia contracta Meek and Worthen				
4. Bellerophon sublævis Hall...	1	0		
F^4—Layer of compact bluish-gray limestone with an occasional fossil.....	1	9		
F^3—Layer of fossiliferous, hard, compact, crystalline limestone. Contains:				
1. Productus pileiformis McChesney				
2. Productus cestriensis Worthen				
3. Pinna maxvillensis ? Whitfield				
4. Bellerophon sublævis Hall...	1	4		
F^2—Layer of fossiliferous bluish limestone...	0	6		
F^1—Layer of bluish, slightly fossiliferous limestone to water level.....	0	9		

The above section will probably be slightly misleading since nothing is said about any shaly partings. Such partings occur, however, between most of the layers. But this exposure has long been subjected to the various agencies of weathering, and, situated as it is in the outer bend of the channel, the stream, at high water, has removed the disintegrated shale. The layers, therefore, project from the face of the bank, somewhat independently of each other. The exposure shows the limestone to be the typical upper zone of the stratum.

Attention should also be called to the occurrence of *Productus*

A.—An exposure of the Maxville limestone in Kents Run opposite the Thompson Residence at White Cottage, showing the medium layers of the upper zone.

B.—A view of the Hendricks Quarry on the west bank of the stream at Maxville. The Sharon conglomerate rests disconformably upon the Maxville limestone.

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pileiformis in layer F^5. It is only rarely that specimens of this fossil are found in the Maxville, but at this locality they are very abundant. Large and beautiful specimens can be had in great numbers. The shells are long and expand suddenly in a trunmpet-shaped manner at the anterior end, thus differing markedly from Whitfield's illustrations.

From Mr. Thompson's residence to White Cottage the limestone is more or less exposed all of the way. It is the typical upper zone and is conspicuously stratified and rather fossiliferous. It is a compact, pure limestone of a bluish or bluish-gray color.

In the stream at the east bluff, nearly half way between the Thompson residence and White Cottage, about sixteen inches of the limestone are exposed just beneath the soil. These sixteen inches constitute two layers which are rather fossiliferous and so exposed that collecting is facilitated. The following is a list of specimens from this place:

1. Martinia contracta Meek and Worthen
2. Productus pileiformis McChesney
3. Dielasma turgida Hall
4. Productus cestriensis Worthen
5. Derbya crassa Meek and Worthen
6. Allorisma maxvillensis Whitfield
7. Schizodus chesterensis ? Meek and Worthen
8. Bellerophon sublævis Hall
9. Bellerophon sp.
10. Bulimorpha melanoides Whitfield
11. Sphærodoma subcorpulentus ? Whitfield
12. Straparollus similis ? Meek and Worthen
13. Naticopsis ziczac Whitfield
14. Nautilus pauper ? Whitfield

At White Cottage the formation has already been described in the Gladstone Mill section. In the town a few wells, which were drilled for water, however, penetrated the limestone. The records of two of these are very suggestive and probably ought, therefore, to be presented.

Section of the drilled well at C. W. Stine's Home.

	Ft.
Soil	8
Compact blue limestone	16±
Shaly rock	1½
Hard blue sandstone, probably had some lime in it	8

Section of the drilled well at J. H. Dolling's Residence.

	Ft.
Gravel or alluvium	20
Compact blue limestone	16
Little shale	0
Blue sandstone	12
White sandstone, white as marble	12
Blue shale not passed through	46½

The sixteen feet of compact limestone unquestionably belong to the Maxville and probably to the upper half. The subjacent shaly rock in either well—of one and a half feet in thickness in the Stine well—is probably the shale-nodular zone. Then arises the question—and it must always be admitted to be a difficult one to interpret well records other than those made by a core drill—to what formation to assign the next two intervals in the Dolling's well? In the churning process the rocks are more or less pulverized. Granting that this is the sandy limestone of the lower half of the Maxville, the little lime could easily be washed away, leaving only the sand. Hence it would be reported as sandstone. Futhermore the sandstone of the second twelve feet is reported as being as white as marble, and no such sandstone is known in the Waverly. The next forty-six and a half feet are blue shales. Both blue shales and blue shales with thin sandstones are found in the upper Waverly to which this interval undoubtedly belongs. The two intervals of twelve feet each are, for the reasons just mentioned, strongly suggestive of the lower half of the Maxville, and if referred to it would give a thickness of forty to forty-one and a half feet for the complete formation. These measurements compare very closely with the thickness of the Maxville at Fultonham as determined by the computations in this paper, and by the well records.

WELLS OF SOUTH FORK OF JONATHAN CREEK AND TRIBUTARIES.

The South Fork of Jonathan Creek rises in Perry County near New Lexington. It flows east and thence north to join Jonathan Creek proper about two miles below, east of, White Cottage. Beyond the junction of the two branches, the stream is known as Moxahala Creek. This name has, also, at times, been applied to the two branches.

As already stated, South Fork in its lower course flows to the north. This portion of the stream is decidedly to the east of Jonathan Creek. The dip of the strata to the east is sufficient to bring the Maxville limestone below drainage before the valley of the former stream is reached. The result is, there are no exposures of this stratum along South Fork. A number of oil wells penetrated the limestone, however, at Sayre, Crooksville and Roseville which are located in this valley.

Mr. O. B. Thompson, of Crooksville, is interested in the gas and oil company of this region. He informed the writer that a well was drilled at Sayre and that it passed through about sixty feet of the Maxville. He further states that there have been three wells drilled at Crooksville, and that the limestone was found in all of them, and varies in thickness from fifty to sixty feet.

Mr. J. H. Been, of Roseville, states that about sixteen wells have been drilled in and about Roseville. The Maxville limestone was found in all of them, and varies from about twenty-eight to forty-seven feet in thickness.

EXPOSURES OF RUSH CREEK AND TRIBUTARIES.

Rush Creek rises in Thorne, the northwestern township of Perry County, and after various wanderings flows south through Rushville to Bremen. At the latter point it crosses the preglacial valley, which extends from New Lexington to Lancaster, and receives Little Rush Creek from the east. From here it continues the southerly course for some miles and then a westerly one to the Hocking River at Sugar Grove.

Little Rush Creek also rises in Perry County, at a point a few miles east of New Lexington. It flows practically due west to its confluence with Rush Creek at Bremen. Through the most of its course it meanders lazily through the old glacial filled valley. The tributaries of this and the main branch and the hills at their headwaters furnish a number of exposures of Maxville limestone.

The Zanesville-Maysville Pike extends southwest from Somerset to Rushville. A half mile south of the pike, and parallel with it for some five miles, is the "State Road." Three and a half miles east of Rushville Station, and at J. S. Shafer's residence, the "State Road" crosses Jockey Hollow. The Maxville limestone is found in the headwaters of three of its branches. Although these exposures are not the nearest to those of Jonathan Creek, by some three miles, they will be described first, as both contacts are shown here.

Section of the east gully of Jockey Hollow at the Shafer Residence.

	Ft.	In.	Ft.	In.
Pottsville shales shown farther up the gully.				
Maxville limestone			19	7
A^6—Partly covered at base. Upper part poorly exposed. Impure yellowish or buff limestone, without conspicuous bedding planes. Badly shattered, due to weathering, and markedly different from A^5 and A^4	15	0		
A^5—Medium to thin, even-bedded, grayish to yellowish sandstone with lime or impure limestone with sand. The rock is brecciated, and contains pieces of pure, compact, fossiliferous limestone. Some pieces reach the magnitude of 3 by 7 inches and are fossiliferous	3	10		
A^4—Layer of yellowish sandstone with some lime or impure limestone with sand, and with an even top and an uneven base. Brecciated with pieces of pure compact limestone of much darker color than the usual color of the Maxville. Varies from one foot ten inches to	0	9		

Probable Disconformity.

	Ft.	In.	Ft.	In.
Rushville "group"			23	6
A^3—Soft, argillaceous shale, bluish-gray to red in color. Some is slightly arenaceous and contains *Taonurus*. The upper surface is uneven and jointed. The joints are often filled with yellowish sandy material, forming "sandstone dykes"	17	0		
A^2—Mostly all covered, some soft, argillaceous blue shale	5	6		
A^1—Layer of reddish to brownish stone, which in places is a crystalline limestone with Crinoid stems, and in others is ferruginous with but little lime. To base of section at the confluence of the two branches	1	0		
Shales and fine-grained sandstones containing *Taonurus* farther down stream.				

Section of the west gully of Jockey Hollow at the Shafer Residence.

	Ft.	In.	Ft.	In.
Pottsville formation			6	3
B^{15}—Arenaceous, dark shales to top of exposure below the road	3	0		
B^{14}—Coal horizon	0	2		
B^{13}—Impure fire-clay	2	10		
B^{12}—Covered. At one place there appears to be a layer of iron ore at this horizon.	0	3		
Maxville limestone total thickness			21	5
B^{11}—Indistinctly-bedded, impure, argillaceous limestone. Weathers to a yellowish or buff color. Contains:				
1. Productus sp	8	0		
B^{10}—Soft, slightly arenaceous, yellowish shale	0	4		
B^9—Indistinctly-bedded, impure, argillaceous limestone, weathers to a yellowish or buff color.				
1. Productus cestriensis Worthen (Robust forms like those from Cut No. 4, F.)	6	3		
B^8—Medium-bedded, compact, bluish limestone. One Bellerophon ? observed.	2	9		
B^7—Soft, argillaceous, blue shale	0	4		
B^6—Layer of pure, compact, bluish limestone with an occasional small, angular piece of darker limestone. Weathers into nodular-like pieces	1	10		

	Ft.	In.	Ft.	In.
B^5—Soft, argillaceous blue shale	0	2		
B^4—Sandstone with some lime or impure limestone with sand. Brecciated, with some pieces of compact, dark limestone. Top even and shaly, remaining portion thick with uneven base. In 8 feet it varies from 2 feet 9 inches to	1	9		
Disconformity or contemporaneous erosion.				
Rushville "group"			23	8
B^3—Soft, argillaceous blue shale with uneven top. Joints filled with the same kind of material as B^4 and this material also extends from the joints along the bedding-planes for a short distance	1	8		
B^2—Mostly covered, some soft argillaceous shale	21	0		
B^1—The same layer as described under A^1	1	0		

More than the usual amount of interest attaches itself to these two sections, because of the excellent exposures of the basal contact of the Maxville limestone. In each one the subjacent shaly interval, A^3 or B^3, as the case may be, has an uneven top. These shales are jointed, and the joints are filled with the same kind of material as that composing the basal intervals, A^4 and B^5, of the Maxville. The same material was forced out from the joints and between the shales for a short distance, as illustrated in figure 3.

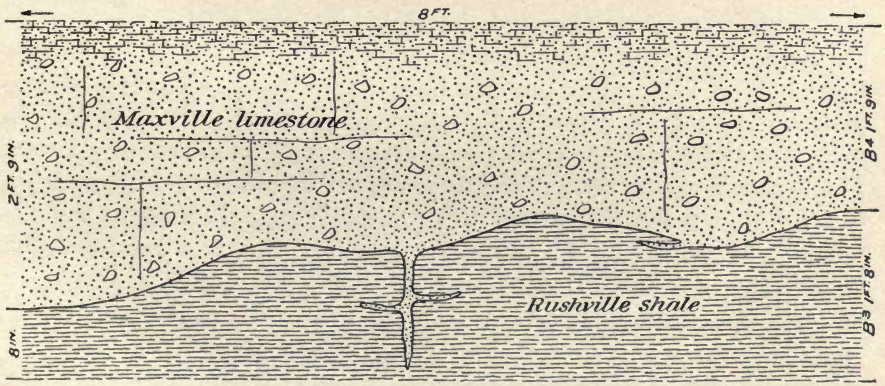


Fig. 3.—A sketch of the Maxville limestone and Rushville shales in Jockey Hollow. Note the uneven contact and that the joints and cracks of the Rushville are filled with the same material as that which makes up the sandy brecciated limestone of the superjacent Maxville.

The basal layer of the Maxville, A^4, in the first section varies from nine inches to one foot and ten inches within the limits of the exposure.

In the second section, the basal layer, B^4, varies from one foot and nine inches to two feet and nine inches within a horizontal distance of eight feet. In both cases the top is even; the variation in thickness being due to an uneven base. From the variations alone it is hard to decide whether this is a case of disconformity or contemporaneous erosion. The filled joints might suggest sun cracks and shallow water during the deposition of the shales, and hence contemporaneous erosion. The joints are not, however, of the usual sun crack variety. Furthermore, data will presently be presented, which further supports the disconformity theory.

When these exposures were first visited, the writer did not include the brecciated calcareous sandstone or sandy limestone, A^4 and A^5 and B^4, in the Maxville limestone, since it differs so markedly from that found in the base of the stratum along Jonathan Creek. Andrews likewise excluded it from the Maxville.[1] More careful study has convinced the writer that it belongs to the Maxville and that its presence is of the utmost significance. Many of the angular pieces in the breccia are limestone. Lithologically they are extremely different from the impure limestone which makes up the mass of the breccia. They are pure, compact limestone and mostly of a color darker than that of the Maxville. Whence is the origin of these angular limestone pieces? Their source could not have been distant or they would have become rounded in transportation. If it were near, then Ohio must have had a Mississippian limestone, other than the Maxville, of which they alone are the representatives. The basal contact, then, is one of disconformity like unto that at the top, rather than contemporaneous erosion.

Aside from the brecciated limestone, B^4, the stratum exposed in the second section is undoubtedly the lower half of the Maxville. On the whole it is a rather impure limestone without distinct bedding-planes. It contains a few badly distorted specimens of the rather robust forms of *Productus cestriensis*. Otherwise it is practically barren. The presence of iron causes the three upper intervals, B^9, B^{10}, and B^{11}, to take on a yellowish or buff tinge, after being subjected to the elements. In this vicinity, and about Maxville, this is called the "buff stone" and that below, the "blue stone."

The twenty-three to twenty-four feet of shales underlying the limestone are also new. Andrews applied the term Rushville group[2] to a stratum of shales occurring between the Logan and the Maxville somewhere in the vicinity of Rushville without locating the type section. These shales in Jockey Hollow undoubtedly belong to the upper part of the group defined by Andrews.

[1]Andrews, E. B. Discovery of a New Group of Lower Carboniferous Rocks in Southeastern Ohio. *Am. Jour. Sci.*, Vol. XVIII, p. 137. 1879.

[2]Loc. cit.

Since an exposure of the Maxville limestone where it is due is the exception rather than the rule, it seems advisable to at least mention every place of known occurrence. In another branch of Jockey Hollow about one-eighth of a mile west of the Shafer residence, is a third exposure, in the lower part of which the stone seems to be fragmental; and in the upper part, to be the "buff limestone." Three miles east of Rushville Station, and a quarter of a mile west of the Shafer home, where a north and south road crosses the "State Road" at the Griffin residence, is a very poor exposure of the limestone. On either side of this north and south road where it unites with the Zanesville and Maysville Pike, at a point half a mile north of the last location, is an old quarry, but each one has so badly fallen in that only a foot or so of the limestone is exposed.

On the Zanesville and Maysville Pike, two hundred yards east of the last place described, is a farm house belonging to G. W. Folk. A like distance north of the house is an old quarry of Maxville limestone. The limestone lies so near the surface that it is badly weathered and does not furnish a satisfactory section. It will, however, be given.

Section of the G. W. Folk Quarry.

	Ft.	In.	Ft.	In.
Sharon conglomerate			0	0
C^3—At about the same horizon as the top of the "Buff limestone" in another part of the quarry are blocks of coarse-grained sandstone, resting upon residual clay	0	0		
Maxville limestone			11	1
C^2—Badly weathered and badly shattered "buff limestone." The weathering has given the stone a decided stratified appearance, but it is probable that the stone was a massive layer as the "buff" was reported to be at Maxville. To top of exposure, which is within three or four feet of the top of the hill	5	6		
C^1—Massive limestone; the lower part blue and with irregular bedding-planes, causing it to appear contorted; the upper part at least stained buff and at least weathered into layers. Base of quarry	5	7		
Two or three specimens of *Productus pileiformis* were collected in this quarry.				

While the close proximity of the limestone to the surface has facilitated the quarrying of the rock, it has also permitted the elements

to work changes which are not desirable to the stratigrapher. The two greatest of these alterations are the shattering of the stone and the change in color. A casual observation of the quarry would leave the impression of abundant stratification, but a study of the same stratum at Maxville and the description of the fresh stone furnished by the owner of one of the quarries at that place, convince one that most of these apparent bedding-planes are due to weathering.

The blocks of Sharon sandstone apparently rest upon residual clay—the probable residue of the upper surface of the Maxville. The base of these blocks seem to be uneven—a condition we should expect to find. A better exposure would no doubt show that they rest disconformably upon the limestone stratum.

A small pit opening, in which are about two and a half feet of bluish-gray shattered limestone, may be seen high up on the east bank of Rush Creek, a half mile north of the Folk quarry, or, more definitely, a half mile north of the Otterbein United Brethren Church. Blocks of Maxville limestone appear in the highway just south of the Ridge School, or about one and a half miles north of the Folk Quarry. These blocks may be from the drift, but their position seems to indicate that they had worked out from the stratum. The formation crosses the highway near the home of Mrs. Alice Baker, which is two and a quarter miles east of Oakthorpe and about half a mile northwest of the Ridge School, but no measurements could be made at this place.

About two miles east of Oakthorpe, and a half mile west of the Baker exposure, is a high hill, the Cover Hill, on which is located Charles Cover's residence. The Maxville limestone was formerly quarried here for road metal, but the face of the quarry is badly covered at the present time. Only two or three feet of the limestone are exposed. The lower part is the "buff limestone." The upper part consists of two layers, the lower one eleven, and the upper one five inches in thickness. Between the two layers is an indistinct, irregular bedding-plane. The stone is badly shattered by weathering since it lies in the very top of the hill. When freshly broken the lower part is a crystalline, bluish-gray stone and the upper two layers are compact, dove-colored limestone resembling lithographic stone.

Prof. G. F. Lamb, of Mt. Union College, examined this exposure before the writer did, and shortly after it had been opened. In his letter dated January 25, 1908, he says: "The whole section obtained was only a little over 7 feet and in 9 different layers of limestone varying in thickness from a fraction of an inch to 1 foot and 4 inches. Scarcely any two of them are alike, varying in purity, compactness, toughness, color. . . . . The partings are sand clay and mixtures of these. It is an interesting exposure, as it shows the very changeable character of the Maxville."

It seems quite possible that some of the layers described by Pro-

fessor Lamb were not natural ones, but were the result of weathering, and that the seven feet were not markedly different from the limestone exposed in the Folk Quarry. The changeable character, mentioned in the letter, has often been attributed to the Maxville. But much of this variability has been shown to be due to a comparison of the limestone in two sections in which the lower half was exposed in one and the upper half in the other, rather than to difference in the stratum itself.

One mile northwest of Redington and in the highway opposite J. H. Gordon's is a poor exposure of Maxville limestone. In the lower part of the exposure the limestone is impure, sandy and brecciated. Some of the larger pieces in the breccia reach a length of three or four inches and are compact, pure, dark limestone. This lower portion is very similar to the lower part of the stratum in Jockey Hollow. Higher, the blocks are impure, bluish limestone, but most of the lime has been leached out, leaving a porous, sandy rock of a brownish color. Near the top, the limestone seems purer, at least it is free from the coarser sand, and weathers to a "buff." Several feet of black, bituminous Pottsville shale apparently rest disconformably upon the stratum. From the lowest limestone block to the upper contact of the Maxville is an interval of sixteen and a half feet.

A number of the exposures mentioned above are worthless as far as sections are concerned. They do show, however, the distribution of the Maxville in this vicinity; an important thing for a formation so frequently "wanting." Isolated exposures appear over a north and south interval of about four miles and an east and west one of two miles —an isolated "hill of Maxville."

The Junction City Clay Products Company's plant is located on the Baltimore & Ohio Railroad, two miles west of the city after which it was named. The company has two "clay banks," the lower one in the Logan, and the upper one in the Pottsville. The following instructive section was measured in the lower quarry.

Section of the Junction City Clay Products Company's Lower Quarry.

	Ft.	In.	Ft.	In.
Immediately above is residual subsoil, whereas 15 or 20 feet above is the base of the upper quarry where fire-clay and shale of Pottsville age are used.				
Sharon conglomerate			2	6
D^2—Layer of coarse-grained sandstone, the base of which is conglomeratic and uneven. Although the face of the quarry was badly plastered by the wash from above, yet this layer apparently rests disconformably upon the next interval.				

	Ft.	In.	Ft.	In.
Logan formation			10	6
D^1—Medium to shaly-bedded, fine-grained buff sandstones to base of exposure, but not of the quarry.				

This exposure is located about three miles southeast of the nearest outcrops of the Maxville limestone, namely, those in Jockey Hollow. And in it the limestone was completely removed before the Sharon was deposited. The next exposures in which the Maxville is present are those of the Monday Creek drainage system, near Maxville, about seven miles still farther to the south.

EXPOSURES ALONG LITTLE MONDAY CREEK AND ITS TRIBUTARIES.

Little Monday Creek rises in Jackson Township, Perry County, at a point about three miles southeast of Junction City. It flows in a southwesterly direction to a point near Webb Summit, where it turns to the southeast and, at Kachelmacher, enters Monday Creek proper. The upper part of the main stream has a southerly course, but after the union of the two branches the resultant stream maintains the southeasterly course of the smaller one and empties into the Hocking River below Nelsonville.

The valley of Little Monday is well within the limits of the Pennsylvanian series, but the stream has cut sufficiently deep, though, to penetrate the Logan sandstone and shale. Along the stream are a number of exposures of the Maxville limestone. These outcrops are in the vicinity of Maxville, the type locality.

The first one of these exposures is in one of the tributaries of Little Monday, a mile north of Maxville. It occurs in the bed of the stream just below James Stimmel's residence. Although only a few inches are exposed vertically, the areal extent is sufficient to show a very important outcrop.

Section of the small stream near the Stimmel Residence.

	Ft.	In.	Ft.	In.
Pottsville formation			1	3
A^3—Massive irregular-bedded sandstone exposed 5 feet up stream from the limestone. Exact contact not shown since it is under water.				
Maxville limestone			1	3
A^2—Shale-nodular zone. Layer of compact bluish-gray limestone which breaks up into rectangular blocks or nodular-like blocks on weathering. Fossiliferous	0	6		

	Ft.	In.	Ft.	In.
A^1—Shale-nodular zone. Blue shale with nodules of limestone scattered through it. Fossiliferous. A harder layer apparently lies below. To base of exposure	0	9		

The following fossils were collected in the two intervals, A^1 and A^2, of the Maxville:

1. Productus cestriensis Worthen
2. Dielasma turgida Hall
3. Seminula subquadrata Hall
4. Allorisma maxvillensis Whitfield
5. Allorisma andrewsi Whitfield
6. Straparollus similis Meek and Worthen
7. Bulimorpha melanoides Whitfield
8. Bellerophon sublævis Hall
9. Cephalopod unidentified.

As already stated, the limestone exists in the very bed of the stream and does not lend itself to easy measurement, but the figures given above are believed to be about correct. A rather large number of species and of individuals of certain species for the Maxville are found here, *Bellerophon sublævis* being very abundant. The abundance of fossils and the appearance in general suggest the shale-nodular zone of the Jonathan Creek and Kent Run sections. To this zone both intervals are referred, although it must be admitted that there is some uncertainty, due to the stratum being covered below.

Lime Kiln Hollow is the name of the small tributary of Little Monday at Maxville. On either side of the stream for two or three hundred yards above the town, the Maxville limestone was formerly quarried for lime. The faces of these old quarries have long since been covered over with surface material. The only remaining exposure is along the bed and bank of the stream, where the following section was made.

Section of Lime Kiln Hollow.

	Ft.	In.	Ft.	In.
Maxville limestone			6	1
B^7—Compact dove-colored limestone apparently composing a single layer	0	10		
B^6—Compact dove-colored limestone apparently forming a single layer	1	0		
B^5—Compact dove-colored limestone	0	9		
B^4—Layer of compact pink or dove-colored limestone, resting upon and partaking of the form of the contorted layer below. The layer is badly shattered and the cracks are filled				

	Ft.	In.	Ft.	In.
with calcite in the form of veins....	0	4±		
B^3—Peculiar, contorted layer of brownish-gray limestone. Contains quartz of fantastic shapes, not exactly angular pieces, yet resembling them.....	0	9±		
B^2—Layer of brownish-gray crystalline limestone.....	1	2		
B^1—Impure dark-brown limestone in hard, thin, wavy layers. To base of exposure under water	1	3		

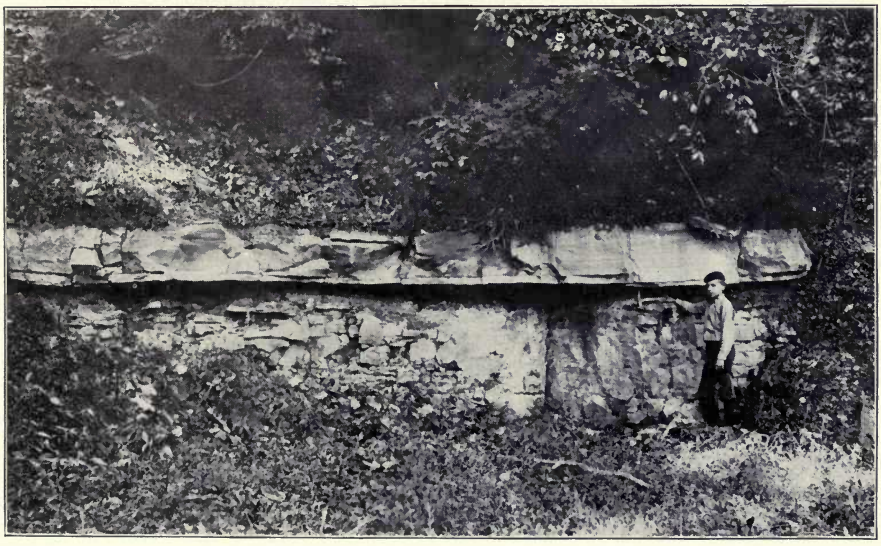
The rather peculiar texture and structure of the stone and the absence of both contacts make the correlation of the zones at this place a somewhat delicate task. The third layer, B^3, is not only peculiarly contorted, but contains quartz in fantastic shapes, and this quartz seems to be quartz of replacement rather than grains of quartz sand. The fourth layer, B^4, partakes of the contorted form of the third layer, B^3, upon which it rests, and is badly shattered, the cracks being filled with calcite veins. These are features which are usually absent in the Maxville. Farther up stream, the limestone above the third layer seems to be purer and lighter in color and in one place to be thrown into a small anticlinal fold. This lighter portion is said to have been the part used for lime and to have measured ten feet in thickness before it was partly covered. The absence of the contacts, as already stated, and also that of the fossils, except a few exceedingly poorly preserved ones which are unidentifiable Bryozoans and Brachiopods, render correlation so uncertain that it will not be attempted.

Another small stream enters Little Monday Creek from the north, at the residence of Daniel Hendricks, a half mile below Maxville. The limestone has been quarried on both sides of this stream for quite a distance. The nearest quarry is on the eastern side about two or three hundred yards above the residence. This is also the most recently operated quarry and hence contains the best exposure.

Section of the Hendricks Quarry on the east bank.

	Ft.	In.	Ft.	In.
Sharon member.....			8	1
C^{13}—Two or three layers of coarse-grained sandstone.....	1	4		
C^{12}—Arenaceous blue shale; usually with iron ore at the base	6	1		
C^{11}—"Graystone." Layer of calcereous sandstone. The layer has an uneven base when C^{10} and C^9 are present, but these are mostly absent, and then the layer has a regular base. In the latter case it appears to rest conformably upon the Maxville. Varies from 1 foot 9 inches to	0	8		

A.—A view of the Maxville limestone and the Sharon member in the Hendricks Quarry on the east bank of the valley at Maxville. The Sharon seemingly rests conformably upon the Maxville at every place in the quarry except this one where the base clearly rises to admit the small remnant of a limestone layer.



B.—Contact of the Maxville limestone and the Sharon member in the same Hendricks Quarry at Maxville. The same basal layer of the Sharon as the one in A. A most beautiful illustration of deceptive conformity.

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Disconformity.

	Ft.	In.	Ft.	In.
Maxville limestone			14	8
C^{10}—Shale, absent except at one place	0	2		
C^{9}—Layer of compact blue ("buff") limestone, with slightly uneven base, absent except at one place	1	3		
C^{8}—Soft shale with a peculiar quartz layer in the base. This forms the top of the stratum throughout nearly all of the quarry. From 9 inches to	0	4		
C^{7}—"Buff stone." Compact blue limestone which weathers to a red or buff on exposure, due to the iron present in it. Shatters badly on exposure, but said to be a single layer	4	10		
C^{6}—"Blue stone." Compact blue limestone with a few irregular bedding-planes. All exposed except a few inches near the base. To base of quarry	4	7		
C^{5}—Zone, with the base of shale, the middle of peculiar quartz material like that in Lime Kiln Hollow, and the top of white limestone. All badly contorted	1	3		
C^{4}—Layer of gray limestone with contorted base	1	1		
C^{3}—Limestone, poorly exposed	1	2		
Undetermined			9	6
C^{2}—Internal covered.				
Logan formation			12	3
C^{1}—Medium to shaly bedded, fine-grained, buff sandstones. Ripple-marked. To base of exposure above the barn.				

Layer C^{11} contains considerable lime—said to be twenty per cent.—and in all places in the quarry except one, and that at first was overlooked, has an even base and top. For these reasons it was at first included in the Maxville limestone. More careful study has revealed the presence at one place of a layer of limestone and a zone of shale, C^{9} and C^{10}, in the top of the Maxville and the rise in the base of layer C^{11} to admit them. Layer C^{11}, therefore, has been made the basal member of the Sharon and undoubtedly rests disconformably upon the Maxville. These features, namely, the uneven base of layer C^{11} and the presence of the intervals C^{10} and C^{9} in one place and layer C^{11} resting in deceptive conformity upon the zone C^{8} due to the absence of the intervals C^{10} and C^{9} in another, are respectively shown in A and B of Pl. V.

On the west bank of the stream, above the quarry just described, are a number of smaller and older quarries. In these the Sharon is not only a massive sandstone, but has a very irregular base. These changes are clearly brought out in the following section.

Section of the Hendricks Quarry on the west bank.

	Ft.	In.	Ft.	In.
Sharon conglomerate			1	7
D^4—Massive coarse-grained sandstone with plant markings. Twelve feet to the east the base of the sandstone passes beneath cover within six inches of the base of the exposure				
Disconformity.				
Maxville limestone			8	6
D^3—Covered, but probably the base of the Sharon also sloped toward the face of the quarry, that is to the south, and rested directly upon this sloping surface	1	11		
D^2—"Buff stone." Blue limestone turning to red or buff when exposed, due to the presence of iron. Badly shattered, but said to be without bedding planes	3	5		
D^1—"Blue stone." Compact blue limestone with indistinct, irregular bedding-planes. To base of exposure	3	2		

This exposure reveals a most beautiful case of disconformity and is nicely shown in Pl. IV, B. Where the section was made the Maxville is eight and a half feet and the Sharon one foot and seven inches in thickness. Twelve feet to the east the base of the Sharon passes beneath the filling of the quarry and to within six inches of the base of the exposure, as illustrated in the following sketch (Fig. 4).

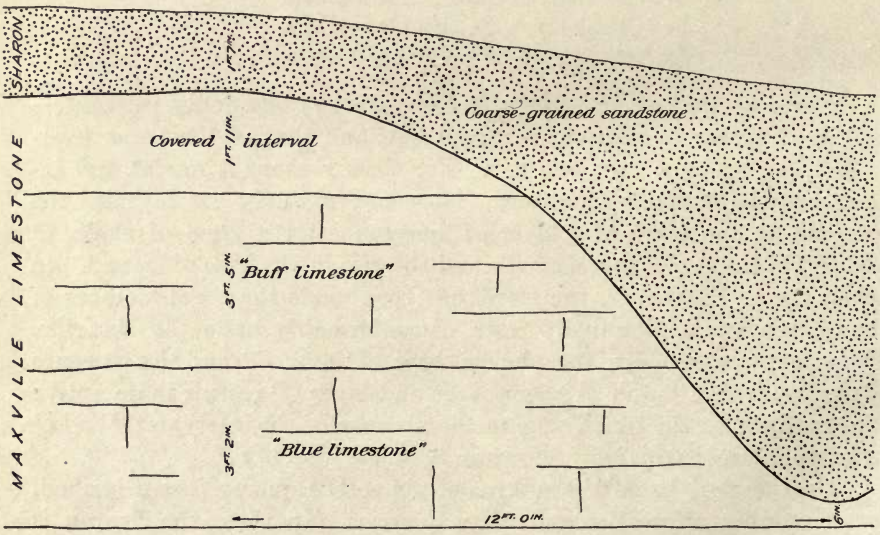

Fig. 4.—The disconformity between the Maxville limestone and the Sharon conglomerate in the Hendricks Quarry on the west bank at Maxville. A sketch of the same rocks as those shown in the photograph in Plate IV, B.

The Maxville has thus suffered at least eight feet of erosion in a horizontal distance of twelve feet. The exposure extends far enough to the east to show that the base of the Sharon begins to rise almost as abruptly as it descended. In the Maxville limestone during the pre-Pennsylvanian age, then, this was an old gully, the life of which was brought to a sudden close by the sediments of Sharon age. About twenty feet to the west the base of the Sharon descends to at least the top of the "blue stone." Here then was another gully. Possibly the two were tributaries—brothers. What a story they might reveal if the Sharon were lifted bodily from them, since further erosion is slightly shown farther up stream.

Passing down Little Monday Creek to a point three-fourths of a mile below Maxville or a mile above the Hocking Valley Railway, one reaches a covered bridge. On the east side of the valley, below the bridge, the Maxville was formerly quarried along its crop. This is the old Howdeshell Quarry.

Section of the Howdeshell Quarry.

	Ft.	In.	Ft.	In.
Sharon conglomerate			3	11
E^5—Layer of gray sandstone with dark stains. To top of exposure	1	10		
E^4—Grayish-black shale with an occasional quartz pebble	1	4		
E^3—Two layers of iron bearing sandstone alternating with arenaceous shale	0	9		
Maxville limestone			4	8
E^2—"Buff stone." Layer of grayish limestone which turns red or buff on exposure. A few inches of the top mixed with, and stained by, iron ore.	3	10		
E^1—Layer of compact, drab limestone	0	10		

On the west side of Little Monday Creek, a half mile north of the Hocking Valley Railway, is the Culver Lime Kiln. Here, in days gone by, the Maxville limestone was burned for lime. It is a later kiln than the one or ones at Maxville, but in either case the lime was transported overland by wagons. The stack stands as a monument to a once rather widely disseminated industry—the death of which is but another tragedy of cheaper railroad transportation.

The Maxville was quarried at the kiln, but the old quarries have filled in with mantle rock. A few hundred yards north or the kiln, about six feet of the limestone is exposed in a small gully, but neither contact is shown. In the upper part of the exposure the limestone is compact and blue and in the lower it is less compact and darker. A loose block showed that peculiar quartz structure already noted at Maxville.

Just east of Webb Summit a cut carries the Hocking Valley Railway from the drainage system of Little Monday Creek into that of the Hocking River. Although the eastern end of this cut is but half a mile south of the last exposure, that is, the one at the Culver Lime Kiln, yet the Maxville has been completely removed and the Sharon rests disconformably upon the Logan. These facts are clearly shown in the following section:

Section of the Webb Summit Cut.

	Ft.	In.	Ft.	In.
Sharon conglomerate			1	4
F^3—Coarse-grained sandstone above and conglomerate below. Contains quartz pebbles, the size of the finger tips. Base slightly uneven				
Disconformity.				
Logan formation			10	9
F^2—Medium-bedded to shaly, fine-grained, buff sandstone	8	6		
F^1—Covered interval, to the Hocking Valley Railway track	2	3		

EXPOSURE ON THREE MILE RUN.

The next and last exposure of the Maxville limestone in the Northern Area is in the valley of Three Mile Run. This stream rises in Falls Township, Hocking County, about a mile south of Webb Summit. It flows south and empties into Hocking River at a point three miles below Logan.

The exposure is on the west bank of the run, just east of Smith Chapel, and is an old quarry where limestone was obtained for furnace flux for old Five Mile or Union Furnace, located five or six miles to the south. Unfortunately the quarry is in an old terrace covered with glacial outwash material and most, if not all, of the overlying Pennsylvanian rocks have been swept away. The face of the old quarry is, furthermore, badly covered, but in spite of this the following interesting section was obtained.

Section of Three Mile Run at Smith Chapel.

	Ft.	In.	Ft.	In.
Maxville limestone			8	10
Apparently shale above..				
A^{10}—Layer of bluish-gray limestone. The fossils are:				
1. Productus cestriensis Worthen				
2. Straparollus similis Meek and Worthen.				
3. Bellerophon sublævis Hall	0	5		
A^9—Shaly parting	0	1		

	Ft.	In.	Ft.	In.
A^8—Layer of slightly argillaceous, bluish-gray limestone. Contains:				
1. Bellerophon sublævis ? Hall	1	3		
A^7—Shale-nodular zone. Bluish, argillaceous shales, which somewhat resemble fire-clay, alternating with nodular layers of limestone. Although not so strikingly fossiliferous as the shale-nodular zone at other places yet it is probably this horizon. The following fossils were collected:				
1. Productus cestriensis Worthen				
2. Dielasma turgida Hall				
3. Seminula subquadrata Hall				
4. Straparollus similis Meek and Worthen				
5. Bellerophon sublævis Hall....	2	7		
A^6—Irregular layer of compact, bluish-gray limestone	1	0		
A^5—Irregular and wavy zone of argillaceous, blue shale.....	0	2±		
A^4—Compact, bluish-gray limestone with a wavy top	0	9		
A^3—Poorly exposed, but mostly shale with nodular layers of blue limestone	0	11		
A^2—Compact bluish-gray limestone, the upper surface of which breaks up badly on exposure.....	1	0		
A^1—Compact, bluish-gray limestone, with an uneven lower surface. The layer itself may be due to a split from the superjacent layer. To base of old quarry	0	8		

Although not all that could be desired, yet this is a most interesting section. A complete exposure with top and bottom contacts shown would be more conclusive evidence in any question of statigraphy, still the section is suggestive. The blue shales alternating with nodular layers of limestone in A^7 resemble the shale-nodular zone to say the least. These shales are also rather fossiliferous, another point in favor of this identification. The medium layers of fossiliferous limestone, A^{10} and A^8, with a shaly parting, A^9, all of which are found above this zone of shales and nodular limestone (A^7), are very much like those layers and partings of the upper zone of the Maxville as exposed along Jonathan Creek. The evidence seems to be all in favor of referring the interval A^7 to the shale-nodular zone.

THE CENTRAL AREA.

The central area extends from Smith Chapel at Logan to Hamden. It includes the southern half of Hocking and the whole of Vinton counties.

Days of search in this field failed to reveal any exposures of the Maxville limestone.

Southwest of Blackjack, a mile and a half to two miles, is the residence of Charles Haggel. In front of his house a small run empties into one of the branches of Pine Creek. The upper Waverly and lower Pennsylvanian rocks are more or less exposed up this run. No Maxville is found here between the Logan and Pottsville, although a very impure limestone exists in the upper part of the Logan. This at first was thought to be a possiple off-shore, sandy representative of the Maxville limestone, for it was believed, by the author, that a stratum of isolated patches of limestone with so wide a distribution must once have been continuous. These patches, it was conceived, might be connected by arenaceous limestone or calcareous sandstone or even by sandstone. Later study has shown the isolated patches to be the result of pre-Pennsylvanian erosion and that these impure limestones in the Logan are in no way connected with the Maxville.

South of the last named place, two and a half or three miles, North Fork of Queer Creek leaves a comparatively wide valley and enters a gorge of Black Hand conglomerate. The passage is over a precipitous face of conglomerate, sixty or eighty feet in height. This is Cedar Falls, and at the falls the creek receives a small tributary from the south. Along this the Logan and Pottsville are exposed, but no Maxville limestone is to be found. The Logan, however, contains some layers of impure sandy limestone.

Ash Cave is a semi-circular or semi-conical cavern in the Black Hand, over which a small tributary of the South Fork of Queer Creek plunges for a sheer drop of ninety-three feet. The cave is located about two miles southwest of Cedar Falls. As one ascends South Fork from the cave the Black Hand and Logan formations are successively mounted and the Pottsville horizon reached at Hue Postoffice. The Maxville is wanting, and the Logan, as usual, contains a few layers of impure limestone or calcareous sandstone.

In this vicinity, about twenty or thirty feet above the very thick conglomerate, appears another conglomerate a few feet in thickness. Mr. Hyde, who is studying the Waverly in this part of the state, claims that this second stratum belongs within the limits of the Logan formation. Should it be the No. II conglomerate forming the top of the Black Hand, then some twenty or thirty feet must be taken from the base of the Logan and added to the top of the Black Hand. The result is a rather thin—as low as fifty or sixty feet—stratum of Logan. A reduced thickness for the Logan is, however, to be expected in this region, since the vigorous erosion, which removed all of the Maxville, more than probably removed a considerable amount of the top of the Logan.

The headwaters of the Middle Fork of Salt Creek are located in Section 14, Jackson Township, Vinton County, about three miles south of those of the South Fork of Queer Creek. In passing down stream one descends the geological scale from the Pennsylvanian to the Waverly series. The rocks are mostly exposed, but the Maxville is not present.

At the Mt. Olive covered bridge, a mile north of Allensville, the Middle Fork of Salt Creek receives a tributary from the east. The rocks are exposed at the confluence and more or less throughout the course of the smaller stream, and especially is this true of the upper half of the creek. The Sharon is here developed as a massive conglomerate. Twenty-two feet are exposed at one place in a vertical section where neither contact is shown, whereas the barometer gave thirty-five to forty-five feet for its complete thickness. It rests disconformably upon the Logan without any remnants of the Maxville limestone.

From the south another tributary enters Middle Fork at Allensville. The upper Waverly and Sharon are also exposed in this tributary. While the exposure at the contact is not the most satisfactory it is sufficient to show the absence of the Maxville.

Other places where the rocks of the Pennsylvanian series rest disconformably upon those of the Waverly could be cited within the Central Area. This scarcely seems necessary since it would only be a repetition of the conditions found in the exposures mentioned above. And furthermore, a point within seven miles of Hamden, which is located in the northern edge of the Southern Area, has now been reached.

THE SOUTHERN AREA.

The Southern Area extends from Hamden on the north to the Kentucky side of the Ohio River on the south. It embraces the margin of Vinton and the whole of Jackson and Scioto counties. Within it are a few small and widely separated areas of the Maxville limestone.

LITTLE RACCOON CREEK EXPOSURES.

Little Raccoon Creek rises at a point about two miles west of McArthur. Its course is mostly a little east of south through Hamden and Wellston to its confluence with Raccoon Creek, south of Vinton. It lies wholly within the limits of the Pennsylvanian rocks, but it has cut sufficiently deep into the strata at Hamden to reach the Maxville limestone and the top of the Logan formation, and to thus give us another inlier of Maxville. Unfortunately an old high level stream, Albany River, which swept through here to the southwest in the ages of long ago, removed practically all of the Pennsylvanian rocks down to the Maxville, so that this contact is hard to find. In spite of this, however, a number of interesting and instructive sections were made.

Nearly a mile east of Hamden is a highway bridge across the present stream. Just above the bridge are the remains of old "Reed's Mill." Here, on the west bank, the first section was measured.

Section at Reed's Mill.

	Ft.	In.	Ft.	In.
Pottsville formation			1	9
A^7—Massive, coarse-grained sandstone above, with some lime below, and with nodules of iron. Probably Pottsville...				
Undetermined			1	0
A^6—Interval covered.				
Maxville limestone			18	5
A^5—Coarse-grained, sandy limestone, gray in color	0	5		
A^4—Mostly covered, some arenaceous gray limestone	4	0		
A^3—Massive, coarse-grained, sandy limestone, grayish in color. It is without distinct or any bedding-planes, except those cross-bedded ones which in some places occur near the base of the interval. At places this interval is separated from the subjacent one by a softer zone only, while at other places the two are not separable, and then they form but a single massive layer. The sand consists of pure white grains of quartz. In places the limestone is brecciated	6	6		
A^2—Massive limestone, without definite bedding-planes, but in places it tends to split up and appears slightly cross-bedded. The limestone is gray in color and sandy, the grains being of white quartz. It is also brecciated. the angular pieces in many places consisting of compact, pure limestone of different colors and markedly different from the mass of the stratum. The lower part contains small, irregular nodules of chert	7	6		
Undetermined			2	0
A^1—Interval covered to water level.				

Banks of Maxville limestone are found first on the one and then on the other side of this meandering stream, as one ascends it for a few hundred yards. They are of about the same height as the one in the section and do not show either contact. At a point about four hundred

yards above the site of the old mill, seventeen feet of the Sharon suddenly descend to water level and cut out the Maxville. A few hundred feet still farther up stream the Maxville again appears in the same bank in about its normal thickness. This is conclusive evidence that the upper surface of the Maxville suffered erosion in Paleozoic time and that the Sharon was deposited disconformably upon the limestone.

About four hundred yards below Reed's Mill, Little Raccoon Creek is crossed, in turn, by the Baltimore & Ohio Southwestern Railroad. A hundred yards above the railroad bridge and on the east bank of the stream is an exposure of the Maxville limestone. Here the following section was made, but the water level in this section is slightly higher than it was given in the Reed's Mill section because a small dam has been built at the railroad bridge since the mill section was measured.

Section above the Baltimore & Ohio Southwestern Railroad Bridge.

	Ft.	In.	Ft.	In.
Pottsville formation			0	7
B^7—Coarse-grained, brown sandstone with much iron ore, to top of exposure				
Undetermined			5	0
B^6—Interval covered				
Maxville limestone			12	0
B^5—Coarse sandstone with some calcite, some lime and much iron. This is probably one of the breccia horizons	1	9		
B^4—Massive, coarse-grained, sandy limestone, without any distinct bedding-planes, but with some irregular pockets of shale. If the section were more accessible, it might show that it was brecciated	8	0		
B^3—Arenaceous gray limestone, cross-bedded, like that at Limeville and Carter Caves, Kentucky	1	9		
B^2—Very impure, sandy limestone of a bluish-gray color. It is more indurated than the overlying interval. Contained one Pelecypod shell	0	6		
Undetermined			1	0
B^1—Interval covered to water level.				

As previously stated, the last exposure is only one hundred yards above the Baltimore & Ohio Southwestern Railroad bridge. At the east abutment of this bridge, recent excavation has exposed a few feet of the strata. Here the following important section was measured.

Section at the east abutment of the Baltimore & Ohio Southwestern Railroad Bridge.

	Ft.	In.	Ft.	In.
Pottsville formation			2	7
C^6—Black, bituminous shale with coarse arenaceous and ferruginous material at the base. Undoubtedly Pottsville formation. To top of exposure.				
Undetermined			3	2
C^5—Practically covered, but probably shale.				
Logan formation			6	1
C^4—Layer of fine-grained buff sandstone, which may be part of layer C^2	0	6		
C^3—Soft, argillaceous white shale, which may only occur in pockets	0	1		
C^2—Massive layer of fine-grained buff sandstone, which may break up into thin layers	3	0		
C^1—Thin-bedded, fine-grained buff sandstone, with a nodular lentil of iron ore. To present water level, which is two or three feet below the top of the dam	2	6		

Here, then, are two sections within a hundred yards of each other. In the one there are twelve feet of the Maxville exposed and there is a possibility of five or six feet being added to the thickness of the formation. In the other one there is no Maxville exposed and the probabilities are that the covered interval, C^5, of three feet and two inches, belongs to the Pottsville shale, rather than to the Maxville. In short, the Maxville has been either practically or completely removed in the lower section, whereas there are at least twelve feet in the upper one.

The Baltimore & Ohio Southwestern has somewhat recently built a new bridge at this place, and the new abutments and arch approaches are concrete structures. The blocks of the old stone abutments were pushed aside and among them are a number of limestone ones which were quarried from the Maxville. These blocks of limestone are much more accessible for study than is the formation along the banks of the stream, and in them the limestone is mostly sandy and impure, and is commonly brecciated. The sand is a white quartz, the grains of which are rounded. The angular pieces, forming the breccia, are mostly limestone of a different color and of a much purer composition than the matrix of the stratum, and many of them reach a length of one or two inches. Scattered among the other material of the breccia are patches of calcite crystals. In some of the blocks there are irregular pieces of chert similar to those in the Mississippian limestone at Carter's Caves, Kentucky.

When first studied these exposures were rather perplexing, the limestone being so different from the pure upper half or, for that matter, from the argillaceous lower half of the formation as exposed along Jonathan Creek. For this reason the exposures at Hamden were first thought to represent a slightly younger formation. It was conceived that the Maxville had been completely shattered and worked over and into this a new sandy, brecciated limestone stratum of Sharon or pre-Sharon age. Neither were there any fossils to aid in the determination of its age. Later studies of the Mississippian limestone farther to the south show, however, that this is also of Mississippian age, and that the stratum becomes more and more sandy for an ever increasing thickness. The limestone, too, in many places is cross-bedded—a feature that shows more plainly when the stone is subjected to the elements. This cross-bedding is nicely shown at Carter and strikingly at Carter's Caves, Kentucky.

The angular pieces of limestone in the brecciated portions of the formation at Hamden are worthy of special consideration. As previously stated, these and those in the Jockey Hollow exposures are angular and not water worn. Hence their origin must have been a point close at hand. If close at hand, then they must have been derived from another and earlier limestone stratum or from the breaking up of the Maxville's own stratum. If the latter condition were not the actual one, and it probably was not, then Ohio must have had a Mississippian limestone of age younger than the Logan and older than the Maxville.

EXPOSURES OF THE LITTLE SCIOTO RIVER AND TRIBUTARIES.

The headwater streams comprising the Little Scioto River drainage system have their origin in the southern part of Jackson and Pike counties. After their union the river maintains a southerly course. It discharges into the Ohio River at Sciotoville.

One of these tributaries rises just beyond the eastern border of Hamilton Township, Jackson County, and flows southwest and thence west across the township. In Section 24, at the home of Amos (Son of Enoch) Canter, the stream has penetrated the Maxville. At this place the limestone was formerly quarried to a considerable extent for furnace flux and for road metal, but the quarry has recently been converted into a fish pond by means of a dam. Although the water covers most of the stratum, still enough is exposed to give the following important section.

Section of the Canter Quarry.

	Ft.	In.	Ft.	In.
Pottsville formation			7	2
A^5—Bluish, arenaceous shales and shaly sandstone, to top of quarry	3	0		

	Ft.	In.	Ft.	In.
A^4—Coarse-grained, micaceous sandstone with a trace of iron. In places there are two inches of iron ore above and in places a like amount below the sandstone	0	8 ±		
A^3—Green, flint fire-clay, the upper part white	2	6		
A^2—Irregular layer of iron ore, which in some places is nearly all displaced by chert. The ore passes into fire-clay above and into chert below. The chert adheres to the limestone. The top of the iron ore is wavy, and is 9 inches lower in one place than it is at another, three of four feet away. The contact of the chert with the limestone below could not be examined on account of the water. Varies from 1 ft. 4 in. to	1	0		
Maxville limestone			2	0
A^1—Compact, bluish-gray limestone. Some parts with angular pieces of chert. Water level of the fish pond in the old quarry.				

About two hundred yards below the quarry and at the Canter residence a scarp exposes a little more of the Maxville. The limestone, as shown here, is three feet in thickness and without a bedding plane. It is of a bluish-gray color and contains some chert in its upper surface. Since no fossils are present and since the lower contact is not shown in either the quarry or the scarp, the exact horizon of the stratum cannot be determined, but the massive character and the absence of fossils are suggestive of the St. Louis, as brought out in the correlation portion of this paper.

The well at the Canter residence is only a few feet from the limestone scarp, and the mouth of the well is six or eight feet above the top of the limestone. In digging the well some soil was first encountered and then about ten feet of red clay or fire-clay. The well was continued to a total depth of twenty-three feet without striking any limestone. Since the bottom of the well is at least fifteen feet below the top of the limestone in the scarp, this number must represent the minimum difference in pre-Pottsville erosion at the two places.

The area of this remnant of Maxville is, like many of the others, very small indeed. Down stream it is seen for a few hundred yards. Up stream it soon passes beneath drainage, and from our knowledge of the formation it is not reasonable to suspect that it extends far beneath drainage in this direction.

Frederick Creek rises near South Webster and flows west through Bloom Township, Scioto County, to join the Little Scioto River, just beyond the western border of the township. Its valley is sufficiently deep to expose Mississippian strata for quite a distance within the more general limits of the Pennsylvanian series. The extreme point is a small bank where the highway crosses the clay switch of the Baltimore & Ohio Southwestern Railroad, about opposite the Harbison & Walker Refractories Company's grinding mill. Here the rocks of the following section are exposed:

Section at the Harbison & Walker Mill.

	Ft.	In.	Ft.	In.
Sharon conglomerate			3	0
A^3—Very coarse conglomerate, apparently with an irregular base	2	6		
A^2—Soft, argillaceous blue and yellow shale with some sand	0	6		
Logan formation			2	6
A^1—Medium to thin-bedded, fine-grained white and buff sandstone, with peculiar long conical depressions.				

In this section the Maxville limestone was completely removed by pre-Pottsville erosion. The last exposure in which it was seen, namely, the Canter Quarry, is located about eight miles to the north. The next place where the limestone is found is on Niner Ridge, which lies about eight or nine miles to the west.

Three miles and a half north of Sciotoville, the Swager Run highway crosses a high hill, known as the Niner Hill. This hill is, in fact, a very narrow east and west ridge—a divide between those tributaries of the Little Scioto River which flow to the northeast, and those which flow to the southeast. Along the very crest of the ridge is a coarse sandstone, and beneath this sandstone in Section 24, Harrison Township, Scioto County, not only was a fire-clay formerly worked, but also the Maxville limestone. This is on the land of the old Harrison Furnace Company, and they used the limestone as a flux in their furnace. Both the fire-clay and limestone banks have pretty badly fallen in, but through the kindness of Mr. J. A. Shump, who aided in locating these old mines and who furnished much useful information, the writer is able to present the two following sections located near each other. In the first exposure a little of the limestone escaped pre-Pottsville erosion, whereas in the second all of it was removed.

West Section of Niner Ridge.

	Ft.	In.	Ft.	In.
B^6—Soil to top of ridge			2	0
Pottsville formation			15	11
B^5—Massive, coarse-grained gray sandstone	13	2		

	Ft.	In.	Ft.	In.
B^4—Green, argillaceous clay. At another exposure 20 feet away a foot of white clay with one or two sandstone partings appears at the top	2	0		
B^3—Interval in which iron ore nodules occur	0	5		
B^2—Interval of irregular pieces of white chert	0	4		
Maxville limestone			0	6
B^1—Light-colored limestone, exposed by digging down to it. Mr. Shump worked in this mine in 1867 or 1868. He says, all told, 2½ to 3 feet of compact bluish-gray limestone was mined for furnace flux, but the stratum was not constant and thinned out in places.				

East Section of Niner Ridge.

	Ft.	In.	Ft.	In.
C^6—Soil to top of the ridge			3	0
Pottsville formation			13	0
C^5—Massive coarse-grained sandstone	10	0		
C^4—Green argillaceous shale	0	5		
C^3—Black argillaceous and carbonaceous shale	1	6		
C^2—Coal	0	1		
C^1—Massive, green, flint fire-clay, "bastard fire-clay." Mr. Shump says that, further in, the fire-clay is of a good quality and 2½ to 3 feet thick, and that it occurs at the same vertical (not geological) horizon that the Maxville did in the previous mine. This is the Sharon fire-clay	1	0		

RECORDS OF WELLS ALONG PINE CREEK AND TRIBUTARIES.

Pine Creek rises somewhere in the southern part of Decatur Township, Lawrence County, and flows to the north and thence to the west, leaving the township near its northwest corner. It enters Scioto County at the southeast corner of Bloom Township. After many wanderings in this county, in Lawrence again, and finally again in Scioto, it discharges into the Ohio River near Wheelersburg.

Its lower or northwesterly course is within Mississippian strata, whereas the remainder of its course, on the other hand, is a long way within the limits of the Pennsylvanian series. A number of well borings and a shaft in two of its head water tributaries have, however, penetrated the Maxville horizon. A careful location of the wells and shaft, before the records are given, is important.

A mile southwest of Olive Furnace, the tributary, flowing southwest through the village, enters Pine Creek. At the side of this tribu-

tary just below town, a well was drilled on the land of McGugin & Co. At this same confluence another tributary enters Pine Creek from the northwest. About two miles above the mouth of the second tributary a well was drilled on the farm of Adam Brandt. A mile and a half above its confluence or a half mile below the Brandt well are the shaft and three wells known as the Harper Shaft and wells.

Mr. Wilber Stout and Mr. C. Ellison McQuigg, former students, very kindly furnished copies of the driller's log of the Brandt and McGugin wells, respectively. Mr. J. L. Harper kindly sent a section of the first well up stream from the shaft. The writer desired to give the records of the shaft and the other two wells belonging to Mr. Harper, in order to bring out the upper disconformity, but did not succeed in obtaining these three records. The sites of all of the wells were located by Mr. John Stout of South Webster, to whom the writer is under special obligation.

Section of the Adam Brandt Well.

	Ft.	In.	Ft.	In.
[Pennsylvanian]			187	6
Surface	2	0		
Sand rock	7	0		
Slate	1	6		
Sand rock	3	3		
Slate	40	10		
Fire clay	4	0		
Slate	5	6		
Sand rock	29	0		
Slate	3	0		
Sand rock	2	6		
Slate	24	10		
Coal	0	4		
Fire Clay	2	6		
Sandy slate	3	6		
Sand slate	22	2		
Fire clay (good flint)	2	10		
Soft, red mottled fire clay	26	0		
Talc [?]	2	6		
White rock	4	3		
Waverly			46	8
Blue sandy shale	46	8		

This section is an exact copy of the driller's log with the exception of those portions which appear between the brackets [ ], and which have been supplied by the writer. Since no true slates are found in the state, it is, of course, understood that the driller's slate is nothing more or less than the ordinary shale.

Judging from the section as a whole, and especially from the presence of the flint and red fire-clays, it seems more than probable that the

drillers have drawn the Mississippian-Pennsylvanian contact at about the proper horizon. This point of division is also strengthened by the two following sections. The absence of the Maxville is also to be noted, although the well is located within a half mile of the Harper wells where the limestone is rather thick.

Section of the Harper Well just above the shaft.

	Ft.	In.	Ft.	In.
[Pennsylvanian]			164	5
Surface	10	0		
Sand rock	10	0		
Black slate	1	0		
Coal	0	4		
Black slate	1	6		
Grayish blue slate	12	0		
Sand rock	1	0		
Fire clay	6	9		
Black slate	1	6		
Gray slate	1	6		
Fire clay	2	0		
Black slate	1	0		
Gray slate	2	0		
Black slate	1	6		
Diamion [?] coal	1	0		
Sand rock	1	0		
Sand rock	8	0		
Black slate	4	0		
Sand rock	31	0		
Blue sand rock	4	0		
Black slate	16	0		
Coal No. 2	1	0		
Bed rock	6	0		
Conglomerate rock	1	6		
Bone shale	36	0		
Green clay	1	6		
Iron ore	1	4		
[Maxville limestone]			42	2
Limestone	3	0		
Green clay	1	0		
Limestone	5	0		
Dark sandy clay	3	6		
Limestone	4	0		
Clay	0	6		
Limestone	15	0		
Clay	0	8		
Limestone	8	0		
Clay	0	6		
Dark limestone	1	0		
Drill stopped.				

In this section, as in the last one, the zones marked slate are intervals of shale, and the portions within the brackets have likewise been supplied. Otherwise the section has not been changed.

There are a number of reasons for referring the limestone to the Mississippian series and hence drawing the Pennsylvanian-Mississippian line of contact at the place indicated. A green fire-clay, similar to the one in the well, is found just above the Maxville and in the basal portion of the Sharon in quite widely distributed areas in this portion of the state. Then, too, the iron ore lying directly upon the limestone recalls a like condition of the Maxville at so many places throughout its area of outcrop. And last, but not least, is the fauna itself which is of undoubted Mississippian age.

A careful search was made in the material of the shaft dump for organic remains. The limestone layers themselves seemed to be very poor in fossils, but the soft argillaceous shales between yielded quite a number. Although some force had distorted practically all of these, yet the following forms were identified, of which *Rhombopora armata*, *Eumetria marcyi*, and *Cleiothyris hirsuta* have been found only at this place.

1. Blastoid unidentified
2. Crinoids unidentified
3. Septopora rectistyla Whitfield
4. Fenestella serratula Ulrich
5. Rhombopora armata Ulrich
6. Derbya crassa Meek and Worthen
7. Productus cestriensis ? Worthen (badly crushed)
8. Spirifer keokuk Hall
9. Seminula subquadrata ? Hall (badly crushed)
10. Eumetria marcyi Shumard
11. Cleiothyris hirsuta Hall
12. Allorisma maxvillensis ? Whitfield (badly crushed)
13. Bellerophon sp.

Another important feature is the structure of the stratum itself. If the well record be correct, or approximately so, it will be seen that the lower half is rather massive, whereas the upper half is more thinly bedded with clayey or shaly partings. Furthermore, the presence of the shale-nodular zone is strongly suggested by the rather large number of fossils found in the clayey shales of the shaft dump. The positive identification of this zone would definitely reveal the development of the lower and upper zones of the formation in this, the southern, as well as in the Northern Area. Since a study of the shaft itself is impossible because it is filled with water, the determination of these points is not possible, and the lack of this shaft section is the more regrettable.

Mr. H. L. Harper worked in this shaft, and although he did not keep any records yet he was able to give considerable information from memory. The shaft penetrated the limestone for seventeen feet, and

the whole of this interval was made up of layers, varying from eighteen to thirty-six inches in thickness, with shaly partings, varying in turn from one to three inches. The layers were horizontal and even, except the top one. The lower surface of this one was even, but the upper surface was wavy. The iron ore varied from fourteen to twenty-four inches. It was wavy also and conformed to the upper surface of the limestone. Furthermore, the shaft was sunken twenty feet lower than was calculated from the nearest well, the first below the shaft, before the limestone was reached. This information further strengthens our belief in the development of the lower and upper zones and in the disconformity at the top, the latter feature of which is so universally present.

Section of the McGugin & Co. Well.

	Ft.	In.	Ft.	In.
[Pennsylvanian]			157	0
Surface	14	6		
Slate	7	6		
Sand rock	3	6		
Slate (sandy)	3	6		
Slate	2	0		
Sand rock	1	0		
Slate	10	6		
Coal	0	4		
Fire clay	2	0		
Sandy slate	12	8		
Slate	2	0		
Sand rock	36	6		
Slate	25	0		
Fire clay	4	0		
Sandy slate	1	6		
Slate	7	6		
Coal	0	2		
Fire clay	1	0		
Slate	3	4		
Sandy slate	17	6		
Clay	1	0		
[Maxville limestone]			43	0
Marble	3	2		
Clay	0	6		
Marble	5	11		
Clay	3	5		
Marble	3	9		
Clay	0	8		
Marble	15	4		
Clay	1	8		
Marble	8	7		

In this well, as in the others, the driller's slate is not slate at all, but shale. The marble is, undoubtedly, the limestone of the Harper well. Pieces of the limestone which came from the shaft, it will be

recalled, showed some evidence of slight changes, but not sufficiently great to produce a marble. The geologic divisions, on the other hand, may be charged against the writer.

Attention is especially called to the great similarity of the layers of limestone in this well and in the Harper well. As in that well, the lower half is apparently a very thick bedded limestone. The upper half, on the other hand, consists of thinner beds and more intervals of shale.

Professor Orton, in his description of the limestones of Lawrence County, says: "This limestone (Lower Mercer), or the Maxville, was encountered at Olive Furnace in a bore hole, two hundred feet beneath the surface. The core removed was almost white, exceedingly dense, and a very pure carbonate of lime. The thickness was reported about twelve feet."[1] It seems more than probable that the limestone to which Professor Orton referred is the Maxville, although the well is not definitely located. Neither does the depth nor the thickness agree with the limestone in the McGugin or Harper wells. On the other hand, the color, texture, and purity agree very closely with the Maxville, and, on the whole, the evidence points toward the Maxville.

EXPOSURES ALONG THE OHIO RIVER.

By referring to the geologic maps of Ohio and Kentucky, the Mississippian-Pennsylvanian line is seen to extend along both sides of the Ohio River valley for a number of miles above Portsmouth. Formerly the river washed the base of a number of high hills in this vicinity and removed the talus to such an extent that the rocks are frequently exposed practically to their tops. These hills are excellent places for the study of the strata both above and below the line of contact and a number of them have been examined.

At the base of such a hill, between Sciotoville and Portsmouth, is the plant and quarry of the Peebles Paving Brick Company. The Cuyahoga shales are utilized to a height of over one hundred feet, and some 260 feet above the top of the quarry is the upper limit of the Waverly series. The Maxville limestone is wanting, and the Pottsville rests directly upon the Logan.

Another similar hill just west of Sciotoville contains a number of good exposures. According to the barometer, the base of the Pennsylvanian is 200 to 240 feet above the river. The following partial section at the line of contact was made at a point about opposite the Norfolk and Western Railway depot. The section shows the Maxville to be absent at this place also.

[1]Orton, Edward Jr. The Limestone Resources and the Lime Industry in Ohio, *Geol. Surv. Ohio*, Bull. 4, p. 85, 1906.

Section of the hill at the lower end of Sciotoville.

	Ft.	In.	Ft.	In.
Sharon conglomerate			1	3
A^4—Coarse-grained gray sandstone, with plant remains. Although the exposure is only 10 feet long the lower surface is seen to be wavy. In this same member is developed a valuable flint fireclay, which has been extensively worked in this vicinity.				
Disconformity.				
Logan formation			12	6
A^3—Thin-bedded to shaly, fine-grained, light buff sandstone. The layers are about uniform in thickness and horizontal.	2	6		
A^2—Interval covered	3	0		
A^1—Medium to thin-bedded, fine-grained sandstone with *Taonurus* at the top.	7	0		

It has just been shown that the Mississippian limestone is absent in those Ohio River hills at and below Sciotoville. Furthermore, it is not known to be present in any of them on the Ohio side of the valley. The limestone has escaped complete removal by pre-Pottsville erosion, however, on the Kentucky side farther up the river, in the vicinity of Limeville (Tongs P. O.).

Opposite the depot is the residence of John H. Merrill. Back of the residence is a very steep and high hill, in which the Maxville is exposed near the summit. Here the following important section was made.

Section of the John H. Merrill Hill.

	Ft.	In.	Ft.	In.
Undetermined			37	6
B^{18}—Interval covered	9	6		
B^{17}—Horizon from which iron ore was dug.				
B^{16}—Interval covered except a few feet of arenaceous shale at the base	28	0		
Sharon member			19	6
B^{15}—Coarse-grained, medium- to thin-bedded, gray sandstones with zones of iron ore and of soft arenaceous shales. The shales weather back and form shelves of the sandstones. Plant remains	2	4		
B^{14}—A zone of soft, arenaceous shale, which weathers back leaving plant remains suspended from the sandstone layer above	0	6		
B^{13}—Massive layer of medium-grained, gray sandstone, containing plant remains.	7	5		

	Ft.	In.	Ft.	In.
B^{12}—Light gray sandstone with some lime in it.	1	0±		
B^{11}—Sandstone in which iron ore and chert nodules occur	0	9		
B^{10}—Green, flint fire-clay which is filled with small concretions of iron ore and which also contains larger nodules of the same material. Decidedly calcalcareous in places. The contact with the sandstone above and the brecciated layer below is wavy. Varies from 5½ feet to 8 feet	5	6		
B^{9}—Loosely consolidated breccia in which the majority of the pieces are limestone and small. Here and there the breccia contains some iron ore at the top. In some places there is a trace of a green, argillaceous or calcareous shale or fire-clay in a wavy zone at the base. In other places the fire-clay breaks up into branching beds. The whole zone varies from 2 feet to practically zero. It was first placed in the Maxville, but it is probably the Maxville limestone worked over and deposited along with the green fire-clay. If the contact be either at the base or at the top of this zone, it is nevertheless one of disconformity. Because of the cementing of this zone to the top of the layer (B^{8}) beneath and the gradual transition into the fire-clay (B^{10}) above, the contact is not sharply defined. However, where this zone is practically wanting the green fire-clay rests disconformably and sharply upon the hard subjacent layer or upon 2 or 3 inches of less completely consolidated nodular limestone which in turn rests upon the said subjacent layer (B^{8}). In these cases (i. e., where B^{9} is wanting) the upper surface of the subjacent layer (B^{8}) is very wavy and has nearly vertical grooves, resembling slicken-sides. From about 0 to	2	0		
Disconformity.				
The Maxville limestone, total thickness			45	9
B^{8}—Layer of gray or dove-colored, compact, hard, pure limestone with calcite scattered throughout. It is slightly brecciated at the top, the angular				

	Ft.	In.	Ft.	In.
pieces being of a medium size and calcareous. Near the up stream end of the exposure pre-Pottsville erosion completely removed the layer so that in places it has no thickness, whereas in others it reaches	2	9		
B^7—Zone of shales alternating with limestone nodules or layers of limestone nodules. In places the zone is finely brecciated. Especially is this true at the base, where the pieces in many places adhere to the top of the underlying layer. The unevenness of the base of the superjacent layer is also partly due to this tendency on the part of the angular pieces to adhere. The zone as a whole is not so firmly consolidated and weathers back more rapidly than the rest of the stratum. The erosion which in places removed the superjacent layer (B^8) also extended into the upper part of this one, thus giving from 2 feet and 9 inches to 3 feet of erosion in a horizontal distance of 6 feet. The zone, therefore, varies from 2 feet to	0	6		
B^6—Practically all massive, pure, gray or dove-colored limestone with calcite crystals scattered through it. However, in some places, there is a slightly developed zone of shales and nodular layers at the top and also more of a tendency to split into layers. Furthermore, the top is finely brecciated in places, and a portion near the top, in others	16	0		
B^5—Massive limestone without definite bedding-planes. There are, however, irregular horizons along which the limestone may separate more readily, and a part of it when subjected to weathering tends to split up in a manner suggesting cross-bedding. It is mostly an impure, sandy-gray limestone. The sand is composed of small white quartz grains. The stone also apparently contains a few small grains of limestone and some calcite crystals. The very base is shown for a horizontal distance of only six inches, so that it cannot be determined whether or not it rests disconformably upon the Waverly	26	6		

	Ft.	In.	Ft.	In.
Waverly series			241	2
B^4—Soft, argillaceous blue shale	0	5		
B^3—Layer of sandstone in which nodules of impure limestone occur	0	9		
B^2—Massive to thin-bedded, fine-grained buff sandstone. Slightly covered in places			153	0
B^1—Covered to the level of the Chesapeake & Ohio Railway tracks below the depot	87	0		

In the section just given, attention should be called to the massiveness of the stone and to the uncommon and poorly developed bedding-planes. These features, of course, suggest the lower half of the Maxville. However, no fossils are found to assist in this correlation. On the other hand, the cross-bedded appearance, which a portion of the stratum assumes when subjected to weathering, and the presence of sand are features very much like those of the limestone as exposed at Carter, and especially at Carter's Caves, Kentucky. These latter conditions make the stone quite different from the lower zone of the Northern Area and renders correlation with it decidedly uncertain.

The limestone was formerly quarried on the Josiah G. Merrill (now V. E. Thompson) property, about half a mile below Limeville. These quarries are located a short distance up one of the small tributary valleys. Although the quarries have filled up to a considerable extent the following section is still available.

Section of the Josiah G. Merrill Quarry.

	Ft.	In.	Ft.	In.
Pottsville formation			3	1
C^{13}—Green fire-clay, somewhat calcareous	1	6		
C^{12}—Nodular-like pieces of limestone, breccia, and green fire-clay, all of which gradually pass into the green fire-clay above. Probably Maxville limestone worked over and deposited with the green fire-clay	1	7±		
Maxville limestone			15	3
C^{11}—More indurated limestone, which in the lower end of the quarry becomes more compact and pure	0	9		
C^{10}—Shales alternating with nodular and brecciated limestone	1	0±		
C^9—Layer of compact, pure, dove-colored limestone; the nodular and brecciated mass clinging to its upper and lower surfaces gives it an uneven appearance	1	10		

	Ft.	In.	Ft.	In.
C^8—Shales alternating with thin nodular layers of limestone, some of which are brecciated. The shales in the upper part are dark	4	0		
C^7—Layer of compact, pure, dove-colored limestone, which may break up into a number of thin layers. The upper surface is brecciated	1	7		
C^6—Shaly parting	0	1±		
C^5—Layer of compact, pure, dove-colored limestone, which may break up into two layers	0	9		
C^4—Shales, nodular shales and thin-bedded limestone, the latter of which is finely brecciated. In places the lower foot is hard and forms a part of the next lower layer	1	3±		
C^3—Massive layer of compact, dove-colored limestone with a little calcite. Bedding-plane between this and the next lower layer is not conspicuous	2	0		
C^2—Massive layer of compact, dove-colored limestone with a little calcite. Slightly brecciated in places at the top	2	0		
Undetermined			7	4
C^1—Covered to the present base of the quarry. Below are massive blocks of coarse, sandy and brecciated limestone. Still farther down, the buff, fine-grained, Logan sandstones with *Taonurus* are seen for a long distance				

The limestone of this section differs from the last in that the stratification is more conspicuous. The layers are thin or medium in thickness and more or less interstratified with shales. These, therefore, suggest the upper half of the Maxville limestone. Notwithstanding Professor Andrews's report to the contrary[1], no fossils have been found in this or any of the other exposures about Limeville. The question of correlation is, therefore, still an open one.

THE AREA BENEATH THE SURFACE.

The Maxville limestone was found in a number of oil or gas wells far within its zone of outcrop. This region was previously defined as the "Area Beneath the Surface" and includes, primarily, portions of Monroe and Washington counties. The area was quite fully discussed by Dr. Bownocker in his "Bulletin on Oil and Gas," which has

[1]Andrews, E B. Supplemental Report on Perry County and Portions of Hocking and Athens Counties. *Geol. Surv. Ohio*, Vol. III, pp. 817, 818. 1878.

already been abstracted, and since no more work has been done in this field further discussion is unnecessary.

THE FOSSILIFEROUS BLOCKS IN THE SHARON CONGLOMERATE.

The study of the basal conglomerate in Licking County and in the Cuyahoga Gorge and at Boston Ledges in Summit County revealed the presence of fossiliferous blocks. The blocks are flat and somewhat angular, and differ markedly from the rounded quartz pebbles, which constitute the mass of the stratum. If they were originally limestone—and they probably were—the lime has been replaced by silica in nearly every case. Unfortunately the fossils are in the form of either internal or external molds and very poorly preserved, so that specific identification is practically impossible. The Bryozoa and a species of Productus could be Maxville forms. On the other hand, a specimen of a Brachiopod and one of a Pelecypod differ from any of the Maxville fossils. The imperfect preservation of these fossils, then, does not permit of a definite determination of the horizon whence these blocks came.

SUMMARY.

The plane of contact between the Sharon conglomerate and the Maxville limestone cuts across layer after layer of the limestone in many places throughout the whole area of outcrops whereas in many other nearby ones the Sharon rests directly upon the Logan formation. The upper surface of the limestone is thus very uneven, and is the result of erosion to which the stratum was subjected after it had been raised above the waters of the sea and before it was again submerged to receive the deposits of the Sharon. This line of contact, therefore, represents a long period of time—a gap or hiatus—during which there was not only a lack of deposition, but also a very slow removal of considerable material by erosion as well as the slow movements of elevation and depression. This structure is called a disconformity or, in other words, an unconformity between parallel beds, due to erosion.

This erosion (pre-Pottsville) removed all of the Maxville stratum in many places, whereas in many other adjacent ones a greater or less amount of the limestone escaped complete destruction, so that the stratum is now found principally in isolated patches. This condition has at times been attributed to deposition originally in isolated basins, but which in fact is due to pre-Pottsville erosion. The Maxville limestone was at first undoubtedly a continuous deposit, and was later separated into patches by erosion before the deposition of the Sharon.

Along the belt of outcrops extending from a point near Zanesville to the Ohio River near Wheelersburg, and also along the line of inliers just to the east of this belt, these patches of limestone are relatively

large and abundant from the place near Zanesville to Logan, completely wanting from the latter to Hamden, and exceedingly small and widely separated from the latter in turn to the Ohio River. This gives us three natural divisions, or areas, which have for convenience been designated, respectively, the Northern Area, the Central Area and the Southern Area.

In the Northern Area, along Jonathan Creek and Kents Run, th Maxville limestone is divided into a lower and an upper half by a thin zone near the middle of the stratum. This thin zone, the shale-nodular zone of the report, is made up of small nodules or nodular-like layers of limestone, which alternate with shales, and both of which are very fossiliferous. The lower zone consists of a massive, clayey limestone, the bedding planes of which are irregular and very indistinct. In the upper zone the stratification is the conspicuous feature, because the shaly partings found between the thin or medium layers of limestone are commonly weathered away, thus permitting each layer to project apparently independently from the face of the cliff. This zone in many places is fairly fossiliferous, whereas the lower one is generally but sparingly so.

At nearly every place in the Northern Area where the lower contact of the Maxville is exposed, pre-Pottsville erosion has removed all or nearly all of the upper zone, so that the complete thickness of the formation is difficult to obtain. The shale-nodular zone enables one, however, to trace other zones from place to place, and by combining the measurements of these the thickness of the lower and upper halves is secured. The thickness of the lower half was found to be a little greater than twenty-five feet, and that of the shale-nodular zone to average about three feet. The maximum thicknesses of the upper zone is at a point opposite the Fultonham depot and at one nearly a mile below, where this half is, respectively, about fifteen and twenty-two feet. This gives us a thickness of nearly forty-three and fifty feet for the stratum—the maximum thickness in the Northern Area, and one which agrees very closely with that of records of nearby wells. But it must not be understood that this is necessarily the thickness of the complete original formation at either of these places, because in each one the limestone was overlain by soil; and furthermore, if either of these be the upper contact, it is more than probable that at least some of the limestone has been swept away by pre-Pottsville erosion.

Collections of fossils from the limestone at Cut No. 4 and at the Kroft Bridge in the Northern Area and at the Harper Shaft in the Southern Area have raised the number of species of the Maxville fauna from twenty-four to thirty-six. The new forms are:

1. Fenestella serratula Ulrich
2. Rhombopora armata Ulrich
3. Eumetria marcyi Shumard
4. Cleiothyris hirsuta Hall

5. Cypricardella oblonga Hall
6. Dentalium illinoiense Worthen
7. Bulimorpha canaliculata Hall
8. Orthonychia acutirostre Hall
9. Strophostylus carleyana Hall
10. Murchisonia vermicula Hall
11. Orthoceras randolphense Worthen
12. Orthoceras okawense ? Worthen

Of these the 1st, 3d, 4th, 5th, 7th, 8th, 9th and 10th belong to the Spergen Hill (Salem) fauna, which recurs in the Ste. Genevieve limestone and again in the Tribune limestone.

The lower contact of the Maxville limestone is not shown at nearly so many places as is the upper one, but wherever exposed it furnishes an interesting problem for study. Since the lower part of the limestone is decidedly argillaceous in Cuts No. 3 and No. 4, and since there is seemingly no break between this impure limestone on the one hand and the sandstones and shales of the Logan on the other, the line of contact has to be somewhat arbitrarily drawn. It seems probable that the clay and fine sand which were derived from the Logan were more or less worked over and into the basal layers of the Maxville. At Opera Bridge, on Kents Run, the line of contact is much sharper and is slightly wavy. The upper surface of the subjacent shales is decidedly uneven in the Jockey Hollow exposures, and furthermore the joints in the upper part of these shales are filled with the same kind of material as that which forms the coarse arenaceous limestone of the basal layer of the Maxville. At the last place, then, it is quite obvious that the uneven surface upon which the Maxville rests represents at least a plain of contemporaneous erosion, and when the lower layers of the limestone are studied it seems more than probable that the structure is a disconformity.

A thin zone in the basal portion of the Maxville at Jockey Hollow and near Redington in the Northern Area, and more or less of the entire formation at Hamden (and certain zones at Limeville) in the Southern Area, are decidedly brecciated. Many of the angular pieces are limestone, much purer, harder and darker than the coarse, sandy material which constitutes the mass of the breccia, and, for that matter, darker than any of the Maxville. The origin of these angular limestone pieces could not have been distant, or they would have become rounded in transportation, and if near, then Ohio must have had a Mississippian limestone other than and older than the Maxville, of which they alone are the representatives.

The Sharon conglomerate in Licking and Summit counties contains a few rather large and somewhat flat and angular blocks, which are fossiliferous, and which were supposed to have their origin in the Maxville limestone, although the composition of practically all of them is silica rather than calcium carbonate. This may have been their origin, but it cannot be definitely so stated, since the fossils are so poorly preserved that specific identification is practically impossible.

CHAPTER III.

CORRELATION.

INTRODUCTORY STATEMENT.

A number of things contribute to the difficulty of the problem of Maxville correlation. With the exception of a single Pelecypod mold which was found in the section above the Baltimore & Ohio Southwestern Railroad bridge at Hamden, and the fauna which was collected in the Harper Shaft, no fossils were found in the stratum in the Southern Area. In other words, with the exception of the two places just mentioned, no fossils were found south of Smith Chapel at Logan, the southernmost point of the Northern Area, so that the fossiliferous limestone of the latter area is separated from the fossiliferous limestone of northern Kentucky not only by the wide gap of the Central Area, where no limestone is preserved at all, but also by the practically barren limestone of the Southern Area. Of the fossils that are found along the zone of the outcrop (i. e., in the Northern Area) a part of the abundant ones belong to the Salem (Spergen Hill) fauna, which recurs in the Ste. Genevieve limestone and again in the Tribune limestone, and the remaining part of the abundant ones belong to the Ste. Genevieve and Tribune limestones. The abundant fossils are, in themselves, therefore, not completely diagnostic. The stratigraphic correlation is further retarded by the absence of good exposures to the south. The outcrops of Mississippian limestone of East-Central Kentucky seldom show both the lower and upper contacts in the same section. Furthermore, the conspicuous zones are so frequently covered that the tracing of a zone or of zones from place to place is not always satisfactorily accomplished. But the chief factor in this difficult problem is the lack of detailed information of the typical Mississippi area itself. The horizon from which the described fossils came has not always been correctly differentiated, but, on the other hand, has in some cases been referred to a lower formation and in other cases to a higher one. With these difficulties ever in mind a few statements will be made about correlation.

CORRELATION WITH MISSISSIPPIAN FORMATIONS OF EAST-CENTRAL KENTUCKY.

In working out the Mississippian stratigraphy of East-Central Kentucky, under the auspices of the Kentucky Geological Survey, and in company with Dr. Foerste, it soon became evident that the Waverly terrane, especially the lower half, became thinner and thinner

toward the south. In other words, the apex of the thinning formations of the Waverly lies to the south of the state of Ohio. On the other hand, outcrops of Mississippian limestones seemed to be thick in some places and not so thick in others, but on the whole, they seemed to thicken to the south. As there had been an apex to the thinning formations of the Waverly terrane and probably also to the declining number of its formations, so also it was inferred was there a like apex to the limestones. But in the latter case the apex was toward the north, the Ohio area.

That the St. Louis sea at least approached the Ohio area is shown by a number of outcrops of limestone of this age in East-Central Kentucky. The stratum appears in the exposure at Old Landing, below Beattyville, in Lee County, as revealed by the presence of *Lithostrotion? canadense.* The lower half of St. Louis is found in the highway one mile north of Rothwell in Menefee County, as determined by *Lithostrotion? canadense* and *Lithostrotion? proliferum appearing together* near the middle of an exposure of seventy feet of limestone. *Lithostrotion? canadense* shows the presence of the stratum at the "Y" one mile below Blackwater in Morgan County. The most northern place where the coral reveals the presence of the St. Louis is at the Pumping Station at Olive Hill in Carter County. About fifteen feet above the unconformable base, at this place, are small chert nodules which contain fragments of *Lithostrotion? canadense.*

A green or red clay, which resembles a fire-clay, appears in a number of sections. In the Blackwater section, about fifteen feet above the horizon of *Lithostrotion,* are two feet and seven inches of green clay. In the Highland Stone Company's Quarry, a half-mile east of the Pumping Station at Olive Hill, some fifty feet above the base of the limestone, are three inches of green clay with angular pieces of limestone. A nine-inch horizon of red clay, which turns green on weathering, is found about six feet above the base of the limestone at Carter in Carter County. At the very base of the limestone in Deep Cut on the Lewis-Carter county line are nearly ten feet of red clay. Whether or not the clay which appears at these places is one and the same stratum is not known. If it be the same, then the lower portion of the limestone series disappears at Deep Cut, and, furthermore, this portion represents either the whole or a portion of the St. Louis limestone.

On the other hand, there are certain features which suggest St. Louis age for the whole of the Mississippian limestone as exposed at certain places in the Southern Area and for a small portion of the base of the limestone as exposed in a few places in the Northern Area. The St. Louis limestone is brecciated at Rothwell and at Olive Hill, Kentucky, and, according to Weller, brecciated beds are very characteristic of the St. Louis in Illinois. Furthermore, according to the same author, fossils are usually rare in the St. Louis, and occasionally arenaceous material

is met with in the stratum. In the Fluorspar district of Western Kentucky and Southern Illinois the formation is highly arenaceous, according to Ulrich. At Limeville (John H. Merrill Hill), Kentucky, and at Hamden, Ohio, the two limits of the Southern Area, the limestone is more or less brecciated, is barren of fossils, and contains much arenaceous material. Furthermore, upon exposure to the elements, it presents a cross-bedded appearance. A thin zone at the base of the formation near Rushville (Jockey Hollow) and near Redington in the Northern Area is also decidedly arenaceous and brecciated, and differs markedly from the rest of the stratum in this area. Of course, these features are in no wise conclusive of the St. Louis age of the whole stratum at these places in the Southern Area or of the thin lower portion of the limestone at the two places in the Northern Area, but since the St. Louis is known to be developed as far north as Olive Hill, Kentucky, the suggestion of this age should ever be borne in mind.

Whether the line of outcrop of the St. Louis limestone does or does not enter the state of Ohio is not definitely known, but the approach of this line toward the state, as proven by the presence of *Lithostrotion? canadense,* has, nevertheless, a very important bearing on the question of Maxville correlation. The St. Louis was shown to be developed at least as far north as Olive Hill, and furthermore, the stratum appears at the very base of the limestone series. Therefore, it seems more than probable that the Maxville limestone is no older than St. Louis in age, and this conclusion, in turn, tends to eliminate the possibility of a Salem (Spergen Hill) age of the Maxville fauna, and to suggest instead either Ste. Genevieve or Tribune age, since the Salem (Spergen Hill) fauna recurs in these limestones.

CORRELATION WITH MISSISSIPPIAN FORMATIONS OF THE WEST.

The correlation of the Maxville limestone of Ohio, or, more strictly speaking, the correlation of the Maxville of the Northern Area of the state, with the formations of the West (i. e., the Central West) must, in the main, be made on paleontologic evidence. How unsatisfactory these results will be may be judged from the rather chaotic condition of the literature on stratigraphy and especially of that on the geologic distribution of the fossils of that region. However, the refined work of Weller and Ulrich has made something possible along this line.

Before going farther into the subject of correlation it becomes necessary to adopt a table of formations as a basis. The following one is by Ulrich and is copied from page 24 of Professional Paper No. 36 of the United States Geological Survey for this purpose, even though Weller states that "it must be somewhat modified to represent the true relations of Mississippian beds of Illinois."[1]

[1]Weller, Stuart. The Geological Map of Illinois. *Ill. State Geol. Surv.,* Bull. 6, p. 23. 1907.

Table of Formations in the Kentucky-Illinois Fluorite District.

				Names of Formations and Members Used in this Work.		Synonyms and Equivalent Formations in the Mississippi and Lower Ohio Valleys.	
Carboniferous.	Pennsylvanian.		Pottsville group.	Mansfield sandstone.		Mansfield sandstone of Indiana. Coal Measures conglomerate of western Kentucky.	
	Mississippian.	Tennesseean.	Chester group.	Kaskaskia limestone.	Birdsville formation.	Kaskaskia limestone of Hall. Chester limestone of authors. Huron formation of recent Indiana reports is same as Birdsville formation.	
					Tribune limestone.		
				Cypress sandstone.		Aux Vases sandstone of Keyes. Probably also Big Clifty sandstone of Norwood.	
				Ste. Genevieve limestone.	Ohara limestone. Rosiclare sandstone. Fredonia oolitic limestone.	Two upper members referred to as lower Chester by Worthen and Engelmann. Entire formation referred to as St. Louis by Norwood.	
			Meramec group.	St. Louis limestone.		St. Louis limestone of most authors, but not of Englemann, Shumard and Swallow, who do not include two lower formations in the St. Louis limestone. The two upper formations equal, respectively, the Mitchell limestone and the Bedford oolitic limestone of recent Indiana reports.	
				Spergen limestone.			
				Warsaw formation—lacking.			
		Waverlyan.	Osage group.	Tullahoma formation.		Keokuk limestone. Burlington limestone.	Harrodsburg limestone (typical) and Knobstone of Indiana.
			Kinderhook group.			Various formations of the Kinderhook group.	
Devonian.			Chemung group.	Ohio shale.		New Albany shale of Indiana reports. Chattanooga shale. Grassy Creek shale of Keyes.	

In order to bring out more clearly the fossil evidence of the age of the Maxville limestone the geologic distribution of the species is shown, as far as possible, in the following table. Since the stratigraphy of the Harper Shaft is not known in detail and since this is the only place in the Southern Area where fossils have been collected from the limestone, the three species, *Rhombopora armata, Eumetria marcyi* and *Cleiothyris hirsuta,* which are found only at this place, are eliminated from the following discussion and have hence been placed in brackets [ ]. The species have been arranged in a number of columns, those which are found only in the Maxville have been placed in one. Those species the geologic range of which has actually been determined by Ulrich have been placed in one or more of the five columns used by him. Those species which the older literature refers to either the Chester (Kaskaskia) or St. Louis have been placed in their respective columns, whereas those species, the geological range of which is very great or the horizons of which are not carefully designated, have been placed in a single column, called the indeterminate.

	List of Species.	Terranes								
		After Ulrich					Authors			
		Birdsville or Tribune	Ohara	Fredonia	St. Louis	Spergen	Kaskaskia or Chester	St. Louis	Maxville only.	Indeterminate
1	Zaphrentis cliffordana	....	....	....	....	....	....	....	....	x
2	Pentremites elegans	....	....	....	....	....	....	....	....	x
3	Cyathocrinus maxvillensis	....	....	....	....	....	....	....	x	....
4	Septopora rectistyla	....	....	....	....	....	....	....	x	....
5	Fenestella serratula	x	x	x	x	x	....	....	....	....
6	Rhombopora armata	....	....	....	....	....	[x]	....	....	....
7	Derbya crassa	....	....	....	....	....	....	....	....	x
8	Productus pileiformis	....	....	....	....	....	....	....	....	x
9	Productus cestriensis	x	x	....	....	....	....	....	....	....
10	Martinia contracta	....	....	....	....	....	x	....	....	....
11	Spirifer keokuk	....	....	....	....	....	....	....	....	x
12	Dielasma turgida	x	x	x	x	x	....	....	....	....
13	Seminula subquadrata	x	x	x	....	....	....	....	....	....
14	Eumetria marcyi	....	....	....	....	....	....	....	....	[x]
15	Cleiothyris hirsuta	....	[x]	[x]	....	[x]	....	....	....	....
16	Schizodus chesterensis	....	....	....	....	....	x	....	....	....
17	Pinna maxvillensis	....	....	....	....	....	....	....	x	....
18	Allorisma andrewsi	....	....	....	....	....	....	....	x	....
19	Allorisma maxvillensis	....	....	....	....	....	....	....	x	....
20	Cypricardella oblonga	x	....	x	....	x	....	....	....	....
21	Dentalium illinoiense	....	....	....	....	....	x	....	....	....
22	Straparollus similis	....	....	....	....	....	....	x	....	....
23	Holopea newtonensis	....	....	....	....	....	....	....	x	....
24	Bulimorpha melanoides	....	....	....	....	....	....	....	x	....
25	Bulimorpha canaliculata	....	....	....	....	....	....	*x	....	....
26	Sphærodoma subcorpulenta	....	....	....	....	....	....	....	x	....
27	Naticopsis ? ziczac	....	....	....	....	....	....	....	x	....
28	Bellerophon alternodosus	....	....	....	....	....	....	....	x	....
29	Bellerophon sublævis	?	....	x	....	x	....	....	....	....
30	Orthonychia acutirostre	x	....	x	....	x	....	....	....	....
31	Strophostylus carleyana	....	....	....	....	....	....	*x	....	....
32	Murchisonia vermicula	....	....	....	....	....	....	*x	....	....
33	Endolobus spectabilis	....	....	....	....	....	x	....	....	....
34	Nautilus pauper	....	....	....	....	....	....	....	x	....
35	Orthoceras randolphense	....	....	....	....	....	x	....	....	....
36	Orthoceras okawense?	....	....	....	....	....	x	....	....	....
	Total	6	4	6	2	5	6	4	11	5

From the above table it will be seen that after deducting the three species which are found only in the Southern Area (Harper Shaft), thirty-three remain for the Northern Area. Of these thirty-three eleven are from the Maxville alone and five are indeterminate. Of the ten the

geologic position of which has been fixed by the older literature, six are of Chester age and four of St. Louis, but of the four St. Louis ones, the three marked with an asterisk * were originally described from Salem (Spergen Hill) material and hence may have the range of the other species of this fauna. Of the seven the geologic distribution of which has been definitely fixed by Ulrich, two range without interruption from the Salem (Spergen) or earlier to the Tribune-Birdsville; three belong to the recurring fauna of the Salem (Spergen), Fredonia, and Tribune; one appears first in the Fredonia and one appears first in the Ohara.

In forming a just estimate, however, of the faunal evidence it is necessary to take into consideration the relative abundance of the species as well as the relative number of the species. The two most abundant species, *Productus cestriensis* and *Seminula subquadrata,* range upward from the Ohara and Fredonia respectively. Of the two next most abundant, *Bellerophon sublaevis* belongs to the recurring fauna of the Salem (Spergen), Fredonia and Tribune, whereas *Straparollus similis* is confined to the "St. Louis," but this old "St. Louis" may have included anything from the base of the Warsaw to the top of the Fredonia or higher.

The paleontologic evidence as to the age of the Maxville limestone of the Northern Area seems to be about equally divided between the Fredonia and Ohara members of the Ste. Genevieve formation, with the odds in favor of the Ohara.[1]

If the sections of the Ste. Genevieve limestone published by Ulrich on pages 41 to 43 of Professional Paper No. 36 be carefully studied it will be seen that the Maxville limestone of the Northern Area agrees more closely with the Ohara than with any of the other members of this formation. The fossiliferous shale-nodular zone of the Maxville compares very favorably with the fossiliferous shales and thin seams of limestone in zone 5 of Ulrich's section of the Ohara. The beds above zone 5 consist chiefly of thin-bedded limestone and interbedded shales, whereas those beneath are, as a rule, more massive, thus agreeing respectively with the upper and lower zones of the Maxville. Then, too, *Productus cestriensis* is one of the most abundant fossils.

With the paleontologic and stratigraphic suggestions pointing as just indicated and with the unconformity between the Warsaw and

[1]In communications to the writer, Dr. Weller has expressed his belief in the Ste. Genevieve age of the Maxville, and Dr. Foerste in the Ohara member of the Ste. Genevieve formation.

For the benefit of those who have not read the bibliographic portion of this paper, and hence also in justice to the earlier workers, it should be stated that Andrews (1870) from the first suspected the Maxville of being Chester in age, that Meek, in a letter to Andrews (1871) expressed his belief of Chester and possibly also of St. Louis age of the fossils from the Maxville, and that Whitfield (1882), in his descriptions of the fossils from the Maxville, stated that the stratum was the equivalent of the Chester or of the Chester and St. Louis.

Salem (Spergen) and the one between the Ste. Genevieve and Cypress (Weller) in mind the conditions of deposition of the Mississippian strata may be represented graphically as in the following figure (5).

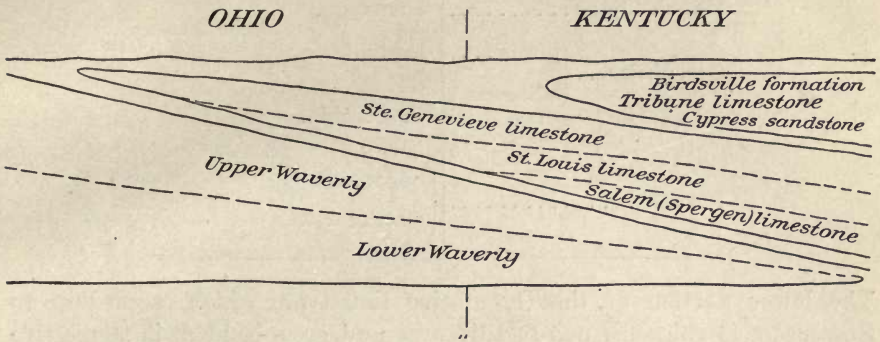

Fig. 5.—A diagrammatic sketch to illustrate the thinning out of a number of Mississippian formations in the Kentucky-Ohio area.

It may be necessary to draw the apex of the St. Louis at Olive Hill, Kentucky, instead of at the place indicated, but, on the whole, the general relationship as represented is probably about correct.

CORRELATION WITH THE MISSISSIPPIAN FORMATIONS OF THE APPALACHIAN REGION.

The Mississippian series of Southern Pennsylvania and adjacent territory is usually divided, in ascending order, into the Pocono, Greenbrier and Mauch Chunk formations. In the bibliographic portion of this paper, however, it was shown that Stevenson (1903) divided the Greenbrier limestone of the United States and Maryland reports into two divisions, a lower, siliceous, non-fossiliferous limestone, and an upper, purer, fossiliferous limestone. Because Weller pronounced the fossils, which Stevenson sent to him from the upper portion of the limestone of Fayette County, Pennsylvania, as practically identical with the Maxville fauna of Ohio, as described by Whitfield in Volume VII of the Ohio reports, Stevenson adopted the term Maxville for this upper division. For the lower portion and for the underlying shales which constitute the lower of the three divisions (according to Stevenson) of the original Mauch Chunk he used the term Tuscumbia. These changes are more clearly shown in the following table:

Usual Divisions.	Stevenson.
Mauch Chunk.....	Shenango.
Greenbrier... pure	Maxville.
Greenbrier... siliceous shales....	Tuscumbia.
Pocono	Logan.

The lower portion of the Greenbrier limestone, which, according to Stevenson, is siliceous, non-fossiliferous and cross-bedded, is suggestive of the whole of the limestone series as exposed at Limeville (John H. Merrill Hill), Kentucky, and at Hamden, Ohio, and of the lower portion of the limestone as exposed near Rushville and near Redington, Ohio.

Collections of fossils of the Greenbrier limestone, from a number of localities in Garrett County in Western Maryland, have, in the present study, been examined and compared with similar ones from the Maxville of Ohio. The Maryland specimens were collected by Professor Prosser and Dr. Richard B. Rowe, under the auspices of the Maryland Geological Survey, at a number of places from Oakland to the Pennsylvania-Maryland state line beyond Friendsville. The following list includes specimens from all of these localities:

1. Archimedes sp.
2. Derbya crassa Meek and Worthen
3. Productus pileiformis Hall
4. Productus cestriensis Worthen
5. Productus sp.
6. Martinia contracta Meek and Worthen
7. Spirifer keokuk Hall
8. Dielasma turgida Hall
9. Seminula subquadrata Hall
10. Eumetria marcyi Shumard
11. Cleiothyris hirsuta Hall
12. Allorisma maxvillensis Whitfield
13. Straparollus similis ? Meek and Worthen
14. Bellerophon sublævis Hall
15. Bellerophon textilis ? Hall
16. Bellerophon sp.
17. Trilobite pygidium

A glance at the above list reveals a Maxville fauna. The four abundant forms, *Productus cestriensis, Seminula subquadrata, Bellerophon sublævis* and *Straparollus similis,* of the Maxville are represented in this list. *Seminula subquadrata* is also abundant in the Greenbrier and

Productus cestriensis is common. Some of the species vary slightly from the same ones of the Maxville, but not sufficiently so for varietal designation. From a faunal study it is clearly seen that the Greenbrier is the Appalachian equivalent of the Maxville limestone of at least the Northern Area of Ohio.

CHAPTER IV.

ECONOMIC GEOLOGY.

INTRODUCTORY STATEMENT.

In the past the Maxville limestone has been used for a number of different purposes. Before the days of cheap transportation it was burned for lime for local consumption at rather a large number of places, and when the Pennsylvanian iron ores of the southeastern portion of the state were utilized the limestone was used as a flux in the then widely distributed charcoal furnaces. It has also been used to some considerable extent for road metal and to a lesser degree for a building stone.

ROAD METAL.

GENERAL STATEMENT.

Of these uses and others yet to be mentioned, it seems to the writer that that of road metal is by far the most important. If the geological map of Ohio be consulted it will be seen that the line separating the Devonian shales on the one hand from the Devonian limestones and older rocks on the other, passes north and south through Columbus and divides the state roughly into two halves. The rocks of the western half are dominantly limestones, whereas those of the eastern half are dominantly sandstones and shales. Passing east from this dividing line across the wide belts of Devonian shales and Waverly sandstones and shales, one finds no limestone until the Maxville is reached, as a scarp at the border line of, or as an inlier just within the limits of, the Pennsylvanian series. Beyond this only here and there is a limestone stratum found and each one of these is, as a rule, very thin and unimportant. The Maxville is thus seen to constitute about the only limestone of much development within this eastern half of the state.

The superiority of limestone over sandstone and shales in highway or pike construction is too well known to elicit much discussion. Sandstones may be harder and more resistant to the wear of vehicles, but they lack the power of cementation so valuable in the limestones, by means of which the road metal becomes a solid block of concrete, thus making an excellent road.

In thus setting forth the economic importance of the Maxville as a source of road material, it is not to be understood that a great local development in a comparatively few places is urged. This would neces-

sitate other than local consumption and bring the limestone into competition with other railway transported limestones, a result that might prove disastrous financially. On the other hand, it is the firm belief of the writer that the limestone should be quarried at practically every place where its isolated exposures show it to be, and the stone so quarried should be used in the immediate vicinity to construct better roads. The roads would not only be wonderfully improved, but the value of the adjacent lands would be greatly enhanced. The beneficial results would thus be more important and far-reaching than in the case of a great local development of one quarry or of a number of them.

In order to further emphasize the importance of this limestone for local consumption in road making it becomes necessary to briefly review the places of occurrence, and this can probably best be done by counties.

MUSKINGUM COUNTY.

This county is one of the richest so far as distribution of the Maxville limestone is concerned. The limestone is exposed for a number of miles from White Cottage up both Kents Run and Jonathan Creek, and could be quarried at a large number of places along both of these streams. At some places it is somewhat more easily accessible and hence some of these should be mentioned.

At the first covered bridge across Kents Run, above White Cottage, and also on the farm of R. G. Thompson the upper part of the Maxville is exposed along the banks of the stream. A little stone has been taken out and a considerable amount could be quarried with the removal of only a small amount of overburden. Both exposures are also very convenient to the highway.

Within the village of White Cottage itself the limestone is exposed in the bed of both streams. Some stone has been removed here and more is readily accessible. A little prospecting would probably reveal a place where considerable could be quarried with the removal of only a small amount of waste.

Near and within the town of Fultonham (Axline P. O.) the upper portion of the Maxville forms the banks of the streams. The stone was formerly quarried to a considerable extent at the depot. This is one of the best places for the development of quite a large quarry, because the stratum forms a terrace ten or fifteen feet above the stream and is covered with only a small amount of material.

PERRY COUNTY.

Numerous railway cuts in Jonathan Creek gorge above Fultonham expose the Maxville in Muskingum as well as in Perry County. Large amounts of stone could be quarried with some difficulty at these places.

It is, also, not so readily accessible for local consumption as a road metal, since the principal highways do not enter the gorge and the two roads which do cross the stream ascend very steep hills on either side. These locations seem better for development along a different line.

In the highway leading northwest from Redington opposite the residence of J. H. Gordon is an exposure of sixteen feet of Maxville. The exposure is rather poor and the stone does not occur under very favorable quarrying conditions, but it may be possible that enough could be obtained for the roads of the immediate vicinity. The limestone outcrops in the road two and a quarter miles east of Oakthorpe, near the home of Mrs. Alice Baker, and a quarter of a mile southwest it occurs at the very top of the Cover Hill just within Fairfield County. At the latter place seven feet were opened up for road material, and a considerable amount of stone could be quarried here with practically no stripping.

Near the Zanesville and Maysville Pike and the Otterbein United Brethren Church, one mile east of the Fairfield-Perry county line, is the G. W. Folk quarry. A rather large amount of stone has been taken from this place for road metal and the quarry is still open. The stratum occurs so near the summit of the hill that very little overburden needs to be removed, and, furthermore, the areal extent at this point may be considerable. Its occurrence at the top of the hill and its close proximity to the highway make this an important quarry.

One mile south of the Otterbein United Brethren Church the state road crosses Jockey Hollow at J. S. Shafer's residence, and just below the road some twenty feet of the Maxville are exposed. A little of the limestone was quarried here for road metal. The thickness of the stratum is sufficient to make this one of the important outcrops where a considerable amount of stone could be quarried.

The next exposures of the stratum take us to the type locality, namely Maxville, in the extreme southern portion of the county. The limestone is exposed at various places along Little Monday Creek; a half mile above Maxville, within the village itself, on both sides of the stream a half or three-quarters of a mile below town, and on the west side a mile and a half below. In Lime Kiln Hollow, within the village, it was at an early date quite extensively quarried and burned for lime, and was also used to some extent for furnace flux. On the Hendricks and Howdeshell properties, a half or three-quarters of a mile below town, it was wrought to quite a considerable extent for both flux and lime. A mile and a half below the village it was quarried for lime, and here may be seen the old kiln still standing and the old log store house in a good state of preservation. The stone could be quarried at any of these places, and especially on the Hendricks and Howdeshell properties, with a very reasonable amount of stripping. The limited north and south in connection with the small east and west distribution should

make the preservation of the limestone at this place one of utmost importance. The stone should experience a growing demand as a road metal.

HOCKING COUNTY.

So far as known, the exposures of the Maxville are limited to one locality in Hocking County. These occur just east of Smith Chapel or about two miles east of Logan. The limestone was formerly quarried here and hauled overland to the old furnace located seven or eight miles to the south at Union Furnace. The stone could be quarried with the removal of a reasonable amount of overburden and is readily accessible to the principal thoroughfares of travel.

VINTON COUNTY.

Like those of the preceding county, the outcrops are limited to one vicinity and this is in the extreme southern portion of the county. Twelve to eighteen feet of limestone are exposed along the banks of Little Raccoon Creek just east of Hamden. The top of the exposures forms a terrace so that the amount of stripping would be very small indeed. These exposures constitute another isolated patch of limestone and this preservation of only a limited area should again add to the value of the stone as a source of road metal.

JACKSON COUNTY.

The limestone is also limited to one locality in this county, and this is in Section 24 in Hamilton Township in the southwestern part of the county. It occurs principally on the land of Amos (son of Enoch) Canter. Long ago it was quarried to a considerable extent for furnace flux and more recently for road metal. The isolation of this small area should also add to its value and it should be eagerly sought after as a road metal.

SCIOTO COUNTY.

The limestone occurs in two or three places in Section 24, Harrison Township. It has been worked for furnace flux along the narrow Niner Ridge, but the areas are too small to be important sources of road metal.

RAILWAY BALLAST.

GENERAL STATEMENT.

Railroads are coming more and more to use crushed stone as a ballast, and especially is this true of limestone. A considerable percentage of the enormous amount of Devonian limestones quarried just west of Columbus is used by the Pennsylvania Railroad for ballast. Large quar-

ries in limestone of Mississippian age at Carter and Olive Hill, Carter County, Kentucky, supply the Chesapeake & Ohio Railway with trainload after trainload of ballast. Likewise a quarry in the same horizon just west of Natural Bridge, Kentucky, furnishes a considerable amount to the Lexington & Eastern Railway.

There is no good reason why in Ohio the Maxville limestone, which is of similar age, should not be used for this same purpose. Especially is this the case at the places now to be mentioned. Of course the item of transportation is not so important as it was in the case of the road metal since the railroads handle their own freight, and yet the extra mileage is a factor which should not be overlooked.

PERRY AND MUSKINGUM COUNTIES.

Various exposures of Maxville along Jonathan Creek are exceedingly convenient to the Zanesville & Western Railway. Especially is this true of those in the village of Fultonham, and, to a less degree, in the cuts above town. The Maxville forms the wide structural terraces opposite the depot in Fultonham, and hence the amount of superjacent waste to be removed would be very small. No more favorable site for a quarry of considerable extent could be desired. Since the Maxville is frequently wanting, due to pre-Pottsville erosion, careful drill tests should precede the expenditure of any considerable amount of money for equipment. The cuts above Fultonham offer similar advantages, and they are even more convenient to the railroad; but a considerable amount of stripping would have to be done at these places.

VINTON COUNTY.

The exposures along Little Raccoon Creek just east of Hamden are adjacent to the Baltimore & Ohio Southwestern Railroad. From twelve to eighteen feet of limestone are exposed along the banks of the stream above water level. Since the stratum forms the structural terrace, already mentioned, the amount of overburden to be removed is small. In all cases where an expenditure of much money is necessary for stationary crushers and other equipment, the areal extent of the stratum should be positively ascertained by drilling.

OHIO RIVER VALLEY.

If the writer may be pardoned for crossing the river, the political boundary in this discussion, something will be said about the exposures at Limeville (Tongs P. O.) Kentucky. It was necessary to do this in the stratigraphic study and it seems to fall within the economic province. The stratum occurs near the summit of the hills, about 250 feet above the Chesapeake & Ohio Railway, and is about fifty feet in thickness.

Formerly it was quarried to a considerable extent and burned for lime. From the quarries on the hill the rough stone could be dropped through chutes to a crusher near the base and from this the crushed product could be loaded by gravity into the car and thus reduce the cost of production.

CEMENT STONE.

GENERAL STATEMENT.

In speaking of Dolomite, (Ca, Mg) CO^3, Bleininger says: "As a cement material it is not promising, since it gives rise to two silicates (of lime and magnesia) which have different rates of hydration and which hence interfere with each other in the hardening process, unless the burning took place at a low temperature not over 1000° C."[1]

Orton and Peppel state that: "Limestone, or mixtures of limestone and shale within the following limits of composition, will be found to be very close to the composition desired in a Portland Cement mixture:

	Per cents.
Silica	15–16
Alumina and ferric oxide	6– 7
Calcium carbonate	74–76
Magnesium carbonate	0– 4.5

"The ingredient which we must watch with greatest care is magnesium carbonate. It must not go beyond 4.5 per cent., and the lower it is the better. If the silica and alumina are too high, we can correct this by throwing out a little clay or shale or adding a little high calcium limestone."[2]

The ban thus placed upon magnesian limestones for cement purposes greatly restricts the area of possible production. About three-fourths of the western half—the limestone half—of the state is underlain with Silurian and Devonian limestones, but these are almost exclusively magnesian. Of the limestones of the remaining one-fourth, Orton and Peppel's analyses show that nearly all of the Ordovician limestone is chemically available for cement purposes, that the composition of the thin Clinton (Silurian) is often favorable, and that a small lentil—the Dayton limestone (Silurian)—which lies just above the Clinton is at some places chemically desirable. All three of these, however, outcrop only in the southwestern part of the state, in the Ordovician area, and in a very narrow belt in the Silurian, adjacent to the former. Their location away from the coal fields is an unfavorable factor, and their manner of outcropping is not always the most desirable. The De-

[1]Bleininger, Albert V. The Manufacture of Hydraulic Cements. *Geol. Surv. Ohio,* Bull. 3, p. 38. 1904.

[2]Op. cit. p. 88.

vonian limestones, on the average, are not chemically adaptable to cement manufacture, the most favorable place being Columbus, and the desirability of the stone at this place has been questioned. The great restrictions thus placed upon the otherwise large limestone areas of the western half of the state by their chemical composition and the location of those chemically desirable beyond the coal fields enhance the value of the limestones of Mississippian and Pennsylvanian age. The location of the Maxville adjacent to, and mostly within, the area of coal bearing rocks is thus seen to be a very important factor.

FULTONHAM AND WHITE COTTAGE.

An analysis was made of samples of the Maxville limestone from a number of different places. The most important of these analyses are of the limestone from Fultonham and White Cottage, since the samples include stone from a number of consecutive feet at the top of the stratum. These two analyses will now be given.

Analysis of the upper twelve feet of the Maxville limestone at Fultonham.

Silica	2.80
Alumina	1.16
Ferric oxide	
Carbonate of calcium	92.80
Carbonate of magnesium	2.13
Total	98.89

Analysis of the top nine feet of the Maxville limestone at White Cottage.

Silica	3.04
Alumina	1.54
Ferric oxide	0.40
Carbonate of calcium	92.92
Carbonate of magnesium	1.21
Total	99.11[1]

Both of these analyses show a limestone admirably suited to the manufacture of hydraulic cement. Attention has already been called to the conditions of the exposure at these places and especially at Fultonham, where the limestone forms the structural terrace opposite the depot and where the amount of stripping necessary to quarry the stone would be small. Then, too, the field lies within the area of the Coal Measures, and although coal is not mined right at Fultonham it is mined at a number of places only a short distance away, and Fultonham is the shipping point where the trains of coal are made up. Furthermore, it

[1]Op. cit. pp. 100, 101.

has been shown in the stratigraphic part of this paper that the upper half of the stratum is fourteen feet and ten inches in thickness opposite the depot and that this division reaches a maximum thickness of twenty-one and a half feet a mile farther down stream. This additional three to ten feet would make the stone just that much more valuable if its chemical composition remains the same, and it probably does. The great variation in lithology and composition which this stratum has been said to undergo from place to place is somewhat misleading. The fact is the upper part has been unintentionally compared with the lower part (as divided in this paper) or *vice versa,* and since the upper and lower halves are decidedly dissimilar, the supposed variation resulted. Attention must again be called to the pre-Pottsville erosion of the upper surface of the stratum and the resultant variation in thickness of the stratum, and hence the necessity of careful tests. The cross section in Fig. 6 will help to illustrate these various points.

OLIVE FURNACE.

Mr. McQuigg furnished an analysis of the limestone which was taken from the McGugin well. Since it is a very pure stone it probably should also be given, although the number of feet included within the analysis is not known. The analysis follows:

SiO_2	1.10
Al_2O_3	0.23
Fe_2O_3	0.17
$CaCO_3$	98.20
$Mg\ CO_3$	0.13
Phos.	0.039
Total	99.869

The analysis reveals a pure limestone well suited to the manufacture of cement, although, as already stated, the amount of limestone included in the sample analyzed is not known. The thickness of the stratum seems to warrant further investigation, even though the limestone would have to be mined by shafting.

FURNACE FLUX.

The Maxville limestone was formerly quarried at a number of places and used at a still larger number for furnace flux. The stone was worked at Maxville and vicinity in Perry County, at Smith Chapel in Hocking County, at Canter's in Jackson County, and on Niner Ridge in Scioto County. The limestone was used in furnaces at Shawnee and at (New) Straitsville in Perry County, in Winona and Union furnaces in Hocking County, in Washington and Jackson furnaces in Jackson County, in Harrison Furnace in Scioto County, and probably in other furnaces.

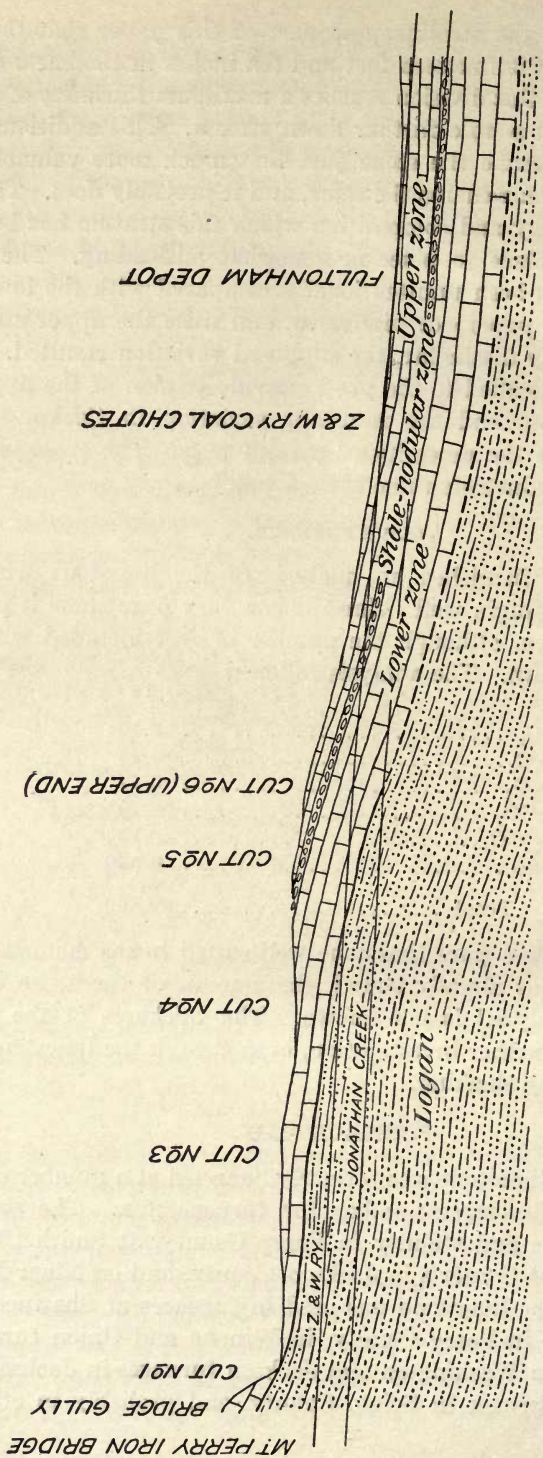

Fig. 6.—A cross section of the Maxville limestone along Jonathan Creek between the Mt. Perry Iron Bridge and a point one mile below the Fultonham Depot. The superjacent rocks have been omitted, but note how the pre-Pottsville erosion plane cuts out the limestone in places and descends deeply into it at others. The sketch shows how one portion of the Maxville is exposed at some points and another portion at others.

These were the old charcoal furnaces, and they obtained their iron ores from the Coal Measure strata of the adjacent hills. But these ores have been practically completely supplanted by the iron ores of the Lake Superior region. The furnaces which they raised and nourished have nearly all passed away with the iron ore industry, and in most cases only piles of rock ruin or heaps of slag remain as monuments to the once widely disseminated industry.

If the Lake Superior District is waning, or in the future should do so, then perhaps the iron ore industry of the Coal Measure hills of Ohio is only slumbering. If slumbering, then perhaps at the awakening the Maxville limestone will again be used as a flux. But this is, at the present, rather too remote a date to warrant further speculation.

There is, however, one kind of furnace flux for which the chemical analyses seem to show the Maxville especially adapted, and that is the flux used by the basic hearth furnaces. These furnaces require a flux as free as possible from silica, SiO_2, and to obtain the desired flux it is often necessary to ship the stone for long distances. One of the Columbus firms, for example, is obtaining limestone at St. Louis, Mo. The analyses already given show the upper twelve feet of the Maxville at Fultonham and the upper nine feet at White Cottage to be low in silica, and the stone from the McGugin well to be very low, and hence at all these places the stone is probably well suited for this use.

LIME.

If the Maxville was rather widely wrought for furnace flux, it was probably even more generally quarried and burned for lime, since the less exacting chemical composition of stone for this purpose wonderfully increased the area of production over that of flux. The Maxville was burned at White Cottage, at Fultonham, rather largely at Maxville, at Canter's in Jackson County, rather extensively at Limeville (Ky.), and probably at many other places. Strata with better natural advantages and better shipping facilities have reduced the competitive price to the critical point, and the Maxville has gone down probably never to rise again in this industry.

FERTILIZER.

The Maxville limestone has been quarried, burned and used as a fertilizer upon the farms where it occurs. It will, probably, be so used again in the future, but such usage can never be other than local.

BUILDING STONE.

The limestone has also been used as a building stone, the court house at Zanesville being constructed of stone from this horizon, quarried at White Cottage. Some of the stone quarried at Fultonham has also been

used for building purposes. At both places the stone is taken from the upper half of the formation, where it is always in definite layers. Since the upper half of the stratum is found to any considerable extent only at these two places, the area of building stone production is very limited. Furthermore, it does not seem probable that it will ever compete with the Berea grit of Ohio or with the Salem (Bedford) oolitic limestone of Indiana.

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